

SECTION B. TECHNICAL NOTES AND TECHNICAL TABLES

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TECHNICAL TABLES

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SURVEY METHODOLOGY

Much of the information for this section was provided by the Manufacturing and Construction Division of the U.S. Bureau of the Census, which collected and compiled the survey data for NSF.²⁰

REPORTING UNIT

The reporting unit for the Survey of Industrial Research and Development is the company,²¹ defined as a business organization of one or more establishments under common ownership or control. The survey includes two groups of enterprises: (1) companies known to conduct R&D, and (2) a sample representation of companies for which information on the extent of R&D activity is uncertain.

FRAME CREATION

The Standard Statistical Establishment List (SSEL), a Bureau of the Census compilation that contains information on more than 3 million establishments with paid employees, was the target population from which the frame used to select the 2000 survey sample was created (see table B-1 for population and sample sizes). For companies with more than one establishment, data were summed to the company level and the resulting company record was used to select the sample and to process and tabulate the survey data.

After data were summed to the company level, each company then was assigned a single North American Industrial Classification System (NAICS)²² code based on payroll. The method used followed the hierarchical structure of the NAICS. The company was first assigned to the economic sector, defined by a 2-digit NAICS code representing manufacturing, mining, trade, etc., that accounted for the highest percentage of its aggregated

payroll. Then the company was assigned to a subsector, defined by a 3-digit NAICS code, that accounted for the highest percentage of its payroll within the economic sector. Finally, the company was assigned a 4-digit NAICS code within the subsector, again based on the highest percentage of its aggregated payroll. Assignment below the 4-digit level was not done because of the concentration of R&D in relatively few industries and disclosure concerns.²³

The frame from which the survey sample was drawn included all for-profit companies classified in nonfarm industries. For surveys prior to 1992, the frame was limited to companies above certain size criteria based on number of employees.²⁴ These criteria varied by industry. Some industries were excluded from the frame because it was believed that they contributed little or no R&D activity to the final survey estimates. For the 1992 sample, new industries were added to the frame,²⁵ and the size criteria were lowered considerably and applied uniformly to firms in all industries. As a result, nearly 2 million enterprises with 5 or more employees were given a chance of selection for subsequent samples, including the 2000 sample. For comparison, the frame for the 1987 sample included 154,000 companies of specified sizes and industries.

DEFINING SAMPLING STRATA

A fundamental change initiated in 1995 and repeated for subsequent samples was the redefinition of the sampling strata. For the survey years 1992–94, 165 sampling strata were established, each stratum corresponding to one or more 3-digit-level SIC codes. The objective was to select sufficient representation of industries to determine whether alternative or expanded publication levels were warranted. For the 1995–98 surveys, the sampling strata corresponded to publication level industry aggregations. For each year, 40 publication levels were defined. These corresponded to the original 25 groupings of manufacturing industries used as sampling strata before 1992 and an additional 15 groupings of non-manufacturing industries. For the 1999 and 2000 surveys, with the conversion to NAICS, 29 manufacturing and

²⁰Copies of the technical papers cited can be obtained from NSF's Research and Development Statistics Program in the Division of Science Resources Statistics.

²¹In the Survey of Industrial Research and Development and in the publications presenting statistics resulting from the survey, the terms "company," "firm," and "enterprise" are used interchangeably. "Industry" refers to the 2-, 3-, or 4-digit North American Industrial Classification System (NAICS) codes or group of NAICS codes used to publish statistics resulting from the survey.

²²The 1999 survey was the first year that companies were classified using NAICS. Prior to 1999, the Standard Industrial Classification (SIC) system was used. The two systems are discussed later under "Comparability of Statistics."

²³Both issues are discussed later in this section.

²⁴See U.S. Bureau of the Census (1994d).

²⁵These industries are listed and discussed below under "Comparability of Statistics."

Table B-1. Survey of Industrial Research and Development—number of companies in the target population and selected for the sample, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Companies in target population	Companies selected for the sample			Companies with reported or imputed R&D expenditures ³		Companies that reported no R&D expenditures ⁴	Other companies ⁵
			Total	Noncertainties ¹	Certainties ²	Greater than or equal to \$5 million	Less than \$5 million		
Distribution by industry:									
All industries.....	21–23, 31–33, 42, 44–81	1,912,456	25,002	21,975	3,027	1,888	1,695	17,741	3,678
Manufacturing.....	31–33	177,312	4,825	3,395	1,430	970	1,010	2,173	673
Food.....	311	2,502	131	76	55	34	42	42	13
Beverage and tobacco products.....	312	278	11	7	4	4	2	5	0
Textiles, apparel, and leather.....	313–16	3,105	244	187	57	11	66	115	52
Wood products.....	321	1,763	111	79	32	3	20	72	16
Paper, printing and support activities.....	322, 323	3,455	106	76	30	27	10	58	11
Petroleum and coal products.....	324	147	16	7	9	8	4	3	1
Chemicals.....	325	1,380	218	76	142	139	40	16	23
Basic chemicals.....	3251	221	62	15	47	46	12	2	2
Resin, synthetic rubber, fibers, and filament.....	3252	102	16	2	14	14	1	1	0
Pharmaceuticals and medicines.....	3254	294	51	8	43	41	4	1	5
Other chemicals.....	325 (minus 3251–52, 3254)	763	89	51	38	38	23	12	16
Plastics and rubber products.....	326	2,773	328	223	105	47	118	103	60
Nonmetallic mineral products.....	327	1,263	131	89	42	17	37	61	16
Primary metals.....	331	1,088	104	61	43	21	36	36	11
Fabricated metal products.....	332	5,627	337	249	88	37	128	137	35
Machinery.....	333	3,561	262	147	115	114	63	56	29
Computer and electronic products.....	334	2,613	530	183	347	300	85	84	61
Computers and peripheral equipment.....	3341	230	70	33	37	43	9	9	9
Communications equipment.....	3342	411	79	21	58	60	7	5	7
Semiconductor and other electronic components.....	3344	1,126	114	24	90	85	12	9	8
Navigational, measuring, electromedical, and control instruments.....	3345	691	160	64	96	100	33	13	14

See explanatory information and SOURCE at end of table.

Table B-1. Survey of Industrial Research and Development—number of companies in the target population and selected for the sample, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Companies in target population	Companies selected for the sample			Companies with reported or imputed R&D expenditures ³		Companies that reported no R&D expenditures ⁴	Other companies ⁵
			Total	Noncertainties ¹	Certainties ²	Greater than or equal to \$5 million	Less than \$5 million		
Distribution by industry:									
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	155	107	41	66	12	24	48	23
Electrical equipment, appliances, and components.....	335	984	110	58	52	51	29	18	12
Transportation equipment.....	336	2,026	219	125	94	85	52	61	21
Motor vehicles, trailers, and parts.....	3361–63	1,387	137	82	55	50	36	38	13
Aerospace products and parts.....	3364	262	24	5	19	19	1	4	0
Other transportation equipment.....	336 (minus 3361–64)	377	58	38	20	16	15	19	8
Furniture and related products.....	337	1,582	180	118	62	10	60	98	12
Miscellaneous manufacturing.....	339	1,982	343	216	127	61	128	103	51
Medical equipment and supplies.....	3391	591	151	93	58	46	55	28	22
Other miscellaneous manufacturing.....	339 (minus 3391)	1,391	192	123	69	15	73	75	29
Other manufacturing.....	31–33 (minus 311–16, 321–27, 331–37, 339)	98	30	7	23	--	--	11	--
Small manufacturing companies ⁶	Fewer than 50 employees	141,085	1,414	1,411	3	1	90	1,094	229
Nonmanufacturing.....	21–23, 42, 44–81	1,726,417	20,088	18,492	1,596	918	685	15,568	2,916
Mining, extraction, and support activities.....	21	2,922	186	124	62	14	20	128	24
Utilities.....	22	554	66	30	36	9	26	23	8
Construction.....	23	78,882	2,056	1,895	161	6	15	1,777	258
Trade.....	42, 44, 45	146,524	3,041	2,946	95	94	54	2,515	378
Transportation and warehousing.....	48, 49	21,842	552	506	46	5	14	447	86

See explanatory information and SOURCE at end of table.

Table B-1. Survey of Industrial Research and Development—number of companies in the target population and selected for the sample, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Companies in target population	Companies selected for the sample			Companies with reported or imputed R&D expenditures ³		Companies that reported no R&D expenditures ⁴	Other companies ⁵
			Total	Noncertainties ¹	Certainties ²	Greater than or equal to \$5 million	Less than \$5 million		
Distribution by industry:									
Information.....	51	12,381	746	495	251	192	66	360	128
Publishing.....	511	5,219	450	264	186	156	50	179	65
Newspaper, periodical, book, and database.....	5111	3,228	177	147	30	5	8	145	19
Software.....	5112	1,991	273	117	156	151	42	34	46
Broadcasting and telecommunications.....	513	3,516	130	98	32	12	3	88	27
Radio and television broadcasting.....	5131	1,628	34	33	1	1	0	29	4
Telecommunications.....	5133	1,577	73	51	22	10	3	43	17
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	311	23	14	9	1	0	16	6
Other information.....	51 (minus 511, 513)	3,646	166	133	33	24	13	93	36
Finance, insurance, and real estate.....	52, 53	38,687	872	819	53	33	15	727	97
Professional, scientific, and technical services.....	54	52,950	3,072	2,330	742	534	376	1,730	432
Architectural, engineering, and related services.....	5413	11,764	926	737	189	69	90	663	104
Computer systems design and related services.....	5415	7,231	846	608	238	167	164	328	187
Scientific R&D services.....	5417	1,472	476	213	263	287	97	45	47
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	32,483	824	772	52	11	25	694	94
Management of companies and enterprises...	55	657	167	116	51	2	11	122	32
Health care services.....	621–23	44,579	1,026	972	54	7	25	877	117
Other nonmanufacturing	56, 61, 624, 71, 72, 81	195,628	2,724	2,684	40	17	23	2,182	502
Small nonmanufacturing companies ⁶	Fewer than 15 employees	1,130,811	5,580	5,575	5	5	40	4,682	853
Unclassified ⁷		8,727	89	88	1	--	--	--	

See explanatory information and SOURCE at end of table.

Table B-1. Survey of Industrial Research and Development—number of companies in the target population and selected for the sample, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Companies in target population	Companies selected for the sample			Companies with reported or imputed R&D expenditures ³		Companies that reported no R&D expenditures ⁴	Other companies ⁵
			Total	Noncertainties ¹	Certainties ²	Greater than or equal to \$5 million	Less than \$5 million		
Distribution by size of company: [Number of employees]									
Total.....	(na)	1,912,456	25,002	21,975	3,027	1,888	1,695	17,741	3,678
5 to 24.....	(na)	1,507,221	11,547	11,522	25	13	220	--	--
25 to 49.....	(na)	220,303	3,992	3,927	65	46	168	--	--
50 to 99.....	(na)	103,055	2,683	2,500	183	134	224	--	--
100 to 249.....	(na)	53,624	2,272	1,923	349	281	285	--	--
250 to 499.....	(na)	14,620	1,251	874	377	240	227	--	--
500 to 999.....	(na)	6,659	986	582	404	222	219	--	--
1,000 to 4,999.....	(na)	5,374	1,439	502	937	525	275	--	--
5,000 to 9,999.....	(na)	752	356	58	298	189	44	--	--
10,000 to 24,999.....	(na)	555	296	49	247	130	27	--	--
25,000 or more.....	(na)	293	180	38	142	108	6	--	--

¹ Noncertainties are companies whose probability of selection is less than one. For more information, see "identifying certainty companies" in the technical notes in this section.

² Certainties are companies whose probability of selection is one. This includes companies whose 1999 R&D expenditures were equal to or greater than \$5 million as well as others included in the sample for analytical purposes ("analytical certainties"). For more information, see "identifying certainty companies" in the technical notes in this section.

³ For information about imputed R&D, see "Probability Proportionate to Size" in the technical notes in this section.

⁴ Includes companies that responded to the survey but did not indicate any information about R&D performance.

⁵ Includes companies that that did not respond to the survey or reported that they were out-of-scope, out-of-business, or had merged with another company (which may or may not have been selected for the survey, and/or may not be in the same industry).

⁶ The frame from which the statistical sample was selected was divided into two partitions based on total company employment. In the manufacturing sector, companies with employment of 50 or more were included in the large company partition. In the nonmanufacturing sector, companies with employment of 15 or more were included in the large company partition. Companies in the respective sectors with employment below these values, but with at least 5 employees, were included in the small company partition. The purpose of partitioning the sample this way was to reduce the variability in industry estimates largely attributed to the random year-to-year selection of small companies by industry and the high sampling weights that sometimes were assigned to them. Because of this, detailed industry statistics were possible only from the large company partition; detailed industry statistics from the small company partition were not possible. Statistics from the small company partition are shown separately and are included in manufacturing, nonmanufacturing, and all industries totals. For more information, see "frame creation" and "sample selection" in the technical notes in this section.

⁷ Companies that were missing or had an incomplete North American Industrial Classification System (NAICS) code at the time of sampling were assigned to an "unclassified" industry category temporarily. If an "unclassified" company reported R&D expenditures, its primary industrial activity was investigated and a NAICS code was assigned during statistical processing.

Table B-1. **Survey of Industrial Research and Development—number of companies in the target population and selected for the sample, by industry and size of company: 2000**

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NOTES: The last four columns in this table account for all of the categories of companies selected for the sample. Companies that responded to the survey are distributed among three categories, those that reported or had imputed R&D greater than or equal to \$5 million, those that reported or had imputed R&D less than \$5 million, and those that had no reported or imputed R&D. Companies that did not respond to the survey, were found to be out-of-scope, out-of-business, or had merged with another company, are included in the last column. Consequently, the sum of the counts in the last four columns equals the counts for total number of "companies selected for the sample."

The total number of "companies selected for the sample" is larger than the "number of companies that received a questionnaire" in Table B-4 because some companies selected for the survey went out of business or were merged with other companies during the time between sample selection and survey mail-out, that is, the sample frame was updated before actual mail-out took place. For more information, see "frame creation" in the technical notes in this section.

KEY: (--) = Indicates data not collected.
(na) = Not applicable.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development: 2000

20 nonmanufacturing strata were defined corresponding to the 4-digit industries and groups of industries for which statistics were developed and published.

IDENTIFYING CERTAINTY COMPANIES

Since industrial R&D is performed by relatively few companies and the national estimate is dependent primarily on large R&D performers concentrated in a small number of industries, it is important to capture and retain large performers for the sample. For this reason some companies are selected with certainty. Since 1996 the criteria for such selection has been total R&D expenditures of \$5 million or more based on data gathered from the prior year's survey (arbitrary certainty) or on predetermined sampling error constraints relating to individual industry estimates (analytical certainty).²⁶

FRAME PARTITIONING

Partitioning of the frame for noncertainty companies into large and small companies was first introduced in 1994 because of concern arising from a study of 1992 survey results which showed that a disproportionate number of small companies was being selected for the sample, and often assigned very large weights. These small companies seldom reported R&D activity. This disproportion was a result of the minimum probability rule (see "Sample Size" below) used as part of the independent probability proportionate to size (pps) sampling procedure employed exclusively prior to 1994 (pps is discussed in detail later under "Sample Selection"). This rule increased the probabilities of selection for several hundred thousand smaller companies. For the 1994 and subsequent surveys, simple random sampling (srs) was applied to the small company partition causing the smaller companies to be sampled

more efficiently than with independent pps sampling since there was little variability in their size (srs also is discussed in detail later under "Sample Selection"). The large company partition continued to be sampled using independent pps sampling.

For the 1994 and 1995 surveys, total company payroll was the basis for partitioning the noncertainty frame. For each industry grouping, the largest companies representing the top 90 percent of the total payroll for the industry grouping were included in the pps frame. The balance, the smaller companies comprising the remaining 10 percent of payroll for the industry grouping, were included in the srs frame.

Beginning with the 1996 survey, total company employment became the basis for partitioning the frame. The total company employment levels defining the partitions were based on the relative contribution to total R&D expenditures of companies in different employment size groups in both the manufacturing and nonmanufacturing sectors. In the manufacturing sector, all companies with total employment of 50 or more were included in the large company partition. In the nonmanufacturing sector, all companies with total employment of 15 or more were included in the large company partition. Companies in the respective sectors with employment below these values were included in the small company partition. In the 2000 survey, the large company partition contained almost 632,000 companies and the small company partition contained approximately 1.3 million companies.²⁷

IDENTIFYING "ZERO" INDUSTRIES

One final modification in the frame development for 1996, which was repeated for the 1997 and 1998 surveys, was the designation of "zero" industries in the large company partition. Zero industries were those three-digit SIC industries having no R&D expenditures reported in survey years 1992–94—the years when estimates by three-digit SIC industry were formed. These industries remained within the scope of the survey, but only a limited sample was drawn from them because it was unlikely that these industries conducted R&D. Simple random sampling was used to control the number of companies selected from these industries. For the 1999 and 2000 surveys, no zero industries were defined because of the

²⁶Before 1994, companies with 1,000 or more employees had been selected with certainty, but it was observed that the level of spending varied considerably and that many of these companies reported no R&D expenditures each year. For these reasons, it was determined that these companies should be given chances of selection based upon the size of their R&D spending if they were in the previous survey or upon an estimated R&D value if they were not. Consequently, the size criterion based on the number of employees was dropped for surveys after 1994. With a fixed total sample size, there was concern that the representation of the very large noncertainty universe by a smaller sample each year would be inadequate. So, to limit the growth occurring each year in the number of certainty cases within the total sample, the certainty criterion was raised for the 1996 survey from \$1 million to \$5 million in total R&D expenditures based on data gathered from the 1995 survey.

²⁷For comparison, these counts in the 1999 survey were 613,257 and 1.3 million, respectively.

conversion to NAICS. For the next several cycles of the survey, NAICS industries will be evaluated to ascertain if any of them should be designated “zero” industries.

SAMPLE SELECTION

Beginning with the 1996 cycle of the survey and repeated for subsequent surveys, a significant revision in the procedure for selecting samples from the partitions led to a change in the development and presentation of estimates. For the 1995 survey, the sample of companies from the large company partition was selected using probability proportionate to size sampling (discussed in detail below) in each of the 40 strata (discussed previously under “Defining Sampling Strata”). Likewise, the simple random sampling of the small company partition was done for each of the 40 strata. However, beginning in 1996, the number of strata established for the small company partition was reduced to two. One stratum consisted of small companies classified in manufacturing industries and the second stratum consisted of small companies classified in nonmanufacturing industries. Simple random sampling continued as the selection method for these two strata.

The purpose of selecting the small company panel from these two strata was to reduce the variability in industry estimates largely attributed to the random year-to-year selection of small companies by industry and the high sampling weights that sometimes occurred. As a consequence of this change, estimates for industry groups within manufacturing and nonmanufacturing were not possible from these two strata as noted on affected tables. The statistics for the detailed industry groups were based only on the sample from the large company partition. Estimates from the small company partition were included in statistics for total manufacturing, total non-manufacturing, and all industries. For completeness, in the affected tables for 1996–98 the estimates also were added to the categories “other manufacturing” and “other nonmanufacturing.” For 1999 and 2000, the estimates were published separately in the “small manufacturing companies” and “small nonmanufacturing companies” categories.

PROBABILITY PROPORTIONATE TO SIZE

Imputing R&D. Except for the companies that were in a previous survey or for which there is information from external sources, it is impossible to know the R&D expenditures for every firm in the universe because R&D

information *is not* available from the Standard Statistical Establishment List (SSEL). Consequently, the probability of selection for most companies is based on estimated R&D expenditures. Since total payroll is known for each company in the universe (payroll information *is* available from the SSEL), it is possible to estimate R&D from payroll using relationships derived from previous survey data. Imputation factors relating these two variables are derived for each industry grouping. To impute R&D for a given company, the imputation factors are applied to the company payroll in each industry grouping. A final measure is obtained by adding the industry grouping components. The effect, in general, is to give firms with large payrolls higher probabilities of selection in agreement with the assumption that larger companies are more likely to perform R&D. Estimated R&D values are computed for companies in the small company partition as well. The aggregate of reported and estimated R&D from each company in both the large and small company partitions represent a total universe measure of the previous year’s R&D expenditures. However, assigning R&D to every company results in an overstatement of this measure. To adjust for the overstatement, the universe measure is scaled down using factors developed from the relationship between the frame measure of the prior year’s R&D and the final prior-year survey estimates. These factors, computed at levels corresponding to published industry levels, are used to adjust the originally imputed R&D values so that the new frame total for R&D at these levels approximates the prior year’s published values. This adjustment provides for better allocation of the sample among these levels.

For 2000, the distribution of companies by payroll and estimated R&D in the large company partition was skewed as in earlier frames (i.e., the correlation of payroll and estimated R&D was high because estimated R&D had been calculated based on payroll). Because of this skewness, pps sampling remained the appropriate selection technique for this group.²⁸ That is, large companies had higher probabilities of selection than did small companies. However, a different approach to pps sampling was introduced beginning with the 1998 survey. Historically, pps sampling had been accomplished using an independent sampling methodology, i.e., the selection (or nonselection) of a given company was independent of the sampling result (select or nonselect) of any other

²⁸Had there been a zero-industry stratum in the 2000 sample, it would have been sampled using srs as discussed previously under “Identifying “Zero” Industries.”

company. This implied that over repeated samplings in a given stratum, different size samples would result. This added more variability to the sample estimates. For 1998, a fixed sample size pps method was introduced. This method ensured that the sample size desired for a given stratum was achieved, thus eliminating error because of sample size variation from the sample estimates. For a given sample size, the fixed sample size method produces more precise estimates on average than the independent method. The fixed sample size methodology was repeated for the 1999 and 2000 surveys.

SIMPLE RANDOM SAMPLING

As described earlier, only two major strata were defined for samples in the small company partition, manufacturing and nonmanufacturing. The use of srs implied that each company within a stratum had an equal probability of selection with the exception of the pre-assigned arbitrary and analytical certainties (discussed previously). The total sample allocated to the small company partition was dependent upon the total sample specified for the survey and upon the total sample necessary to satisfy criteria established for the large partition. Once determined, the allocation of this total by stratum was made proportionate to the stratum's payroll contribution to the entire partition. For 2000, there was also a third srs stratum that contained 8,727 company records where the NAICS code was unknown at the time the sample was selected.²⁹

SAMPLE STRATIFICATION AND RELATIVE STANDARD ERROR CONSTRAINTS

The particular sample selected was one of a large number of samples of the same type and size that by chance might have been selected. Statistics resulting from the different samples would differ somewhat from each other. These differences are represented by estimates of sampling error or variance. The smaller the sampling error, the more precise the statistic.

Controlling Sampling Error. Historically, it has been difficult to achieve control over the sampling error of survey estimates. Efforts were confined to controlling the amount of error due to sample size variation, but this

was only one component of the overall sampling error. The other component depended on the correlation between the data from the sampling frame used to assign probabilities (namely R&D values either imputed or reported in the previous survey) and the actual current year reported data. The nature of R&D is such that these correlations could not be predicted with any reliability. Consequently, precise controls on overall sampling error were difficult to achieve.

For recent surveys, primary concern was placed on controlling error for the large company partition since nearly all of the R&D activity was identified from that portion of the sample. Since 1998, with the introduction of the fixed sample size sampling procedure, the component of sampling error due to sample size variation was eliminated. However, the amount of error attributable to the remaining component of the sample remained. Since there was still no way to predict how well the data from the sampling frame would correlate with actual survey data, the approach taken to allocate the sample across the various strata was to assign probabilities in the same manner as in the past when independent sampling was used. The probabilities resulting from this allocation technique determined the sample sizes to be selected from each stratum subject to the overall sample size constraint dictated by the survey budget. Although the actual survey sampling errors could not be predicted, the parameters used to assign probabilities, and the use of the minimum probability rule resulted in a desirable number of companies being sampled from the large company partition (see "Sample Size" below).

Sampling Strata and Standard Error Estimates.

A limitation of the sample allocation process for the large company partition should be noted. The constraints used to control the sample size in each stratum were based on a universe total that, in large part, was improvised. That is, as previously noted, an R&D value was assigned to every company in the frame, even though most of these companies actually may not have had R&D expenditures. The value assigned was imputed for the majority of companies in the frame and, as a consequence, the estimated universe total and the distribution of individual company values, even after scaling, did not necessarily reflect the true distribution. Assignment of sampling probability was nevertheless based on this distribution. The presumption was that actual variation in the sample design would be less than that estimated, because many of the sampled companies have true R&D values of zero, not the widely varying values that were imputed using total payroll as a

²⁹Companies that were missing or had an incomplete North American Industrial Classification System (NAICS) code at the time of sampling were assigned to an "unclassified" industry category temporarily. If an "unclassified" company reported R&D expenditures, its primary industrial activity was investigated and a NAICS code was assigned during statistical processing.

predictor of R&D. Previous sample selections indicate that in general this presumption held, but exceptions have occurred when companies with large sampling weights have reported large amounts of R&D spending. See table B-2 for a list by industry of the relative standard error estimates for selected items and table B-3 for a list of the relative standard error estimates of total R&D by state.³⁰

Nonsampling Error. In addition to sampling error, estimates are subject to nonsampling error. Errors are grouped in five categories: specification, coverage, response, nonresponse, and processing. For detailed discussions on the sources, control, and measurement of each of these types of error, see U.S. Bureau of the Census (1994b and 1994f).

SAMPLE SIZE

The parameters set to control sampling error discussed above resulted in a sample size of 17,917 companies from the large company partition. For the small company partition, two strata (manufacturing and nonmanufacturing) were identified. Also included was a separate stratum of small companies that could not be classified into a NAICS industry because of incomplete industry identification in the SSEL. In 2000, as in the 1994 through 1999 surveys, a small number of companies was selected from this group in the hope that an accurate industry identification could be obtained at a later point (as discussed above). Ultimately, a final sample of 7,083 companies was selected from the small company and unclassified partitions. Companies in the small manufacturing and unclassified partitions received weights slightly less than 100³¹ and their sample size accounted for one one-hundredth of the population in each partition. The sample size of the “small nonmanufacturing companies” category was the difference between the desired total sample size of 25,000 and the sum of the large manufacturing, small manufacturing, large nonmanufacturing, and unclassified partitions. This total included an adjustment to the sample size based on a minimum probability rule and changes in

the operational status of some companies. With the use of fixed sample size pps sampling for the large company partition and simple random sampling for the small company partition (and with no zero-industry stratum for 2000), the target sample size was met.

Minimum Probability Rule. A minimum probability rule was imposed for both partitions. As noted earlier, for the large partition, probabilities of selection proportionate to size were assigned to each company, where size was the reported or imputed R&D value assigned to each company. Selected companies received a sample weight which was the inverse of their probability. Selected companies that ultimately report R&D expenditures vastly larger than their assigned values can have adverse effects on the statistics, which were based on the weighted value of survey responses. To lessen the effects on the final statistics, the maximum weight of a company was controlled by specifying a minimum probability that could be assigned to the company. If the probability, based on company size, was less than the minimum probability, then it was reset to this minimum value. The consequence of raising these original probabilities to the minimum probability was to raise the sample size. Similarly, a maximum weight for each stratum was established for the simple random sampling of the small company partition. If the sample size initially allocated to a stratum resulted in a stratum weight above this maximum value, then the sample size was increased until the maximum weight was achieved.

Changes in Operational Status. Between the time that the frame was created and the survey was prepared for mailing, the operational status of some companies changed. That is, they were merged with or acquired by another company, or they were no longer in business. Before preparing the survey for mailing, the operational status was updated to identify these changes. As a result, the number of companies mailed a survey form was somewhat smaller than the number of companies initially selected for the survey.

WEIGHTING AND MAXIMUM WEIGHTS

Weights were applied to each company record to produce national estimates. Within the pps partitions of the sample, company records classified in the “other nonmanufacturing companies” category were given weights up to a maximum of 75; company records classified in the remaining NAICS categories were given maximum weights of 50. Within the srs partitions, company records classified in the “small nonmanufacturing

³⁰The relative standard error (RSE) is a percentage that can be added to and subtracted from the published estimate to allow the user to construct an interval with prescribed confidence that the interval includes the actual value. The 1999 and 2000 survey samples were designed to produce RSEs targeted at 2 percent for industries in which there is a large amount of R&D expenditures and 5 percent for industries in which there is a moderate amount of R&D expenditures. For industries in which there is little expenditure for R&D, the RSEs typically are larger.

³¹See “Weighting and Maximum Weights” later in this section.

Table B-2. Survey of Industrial Research and Development—relative standard error for survey estimates, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Number of R&D-performing companies ¹	Domestic net sales of R&D performers	Domestic employment of R&D performers	Number of FTE scientists and engineers	Total R&D	Company and other funds for R&D	Company- financed R&D performed outside of U.S.	Company- financed R&D contracted to outside organizations	Federal funds for R&D
Distribution by industry:										
All industries.....	21–23, 31–33, 42, 44–81	3,583	3.0	2.8	1.6	2.5	2.8	3.2	33.0	1.9
Manufacturing.....	31–33	1,980	2.4	3.9	1.1	0.8	0.9	1.0	4.6	0.7
Food.....	311	76	6.2	21.3	5.1	(D)	10.6	(S) 0.8	50.5	(D)
Beverage and tobacco products.....	312	6	2.6	3.7	1.3	0.8	0.8	(D)	(D)	0.0
Textiles, apparel, and leather.....	313–16	77	9.6	9.2	5.1	(D)	5.7	(D)	48.0	(D)
Wood products.....	321	23	5.0	5.8	(S) 4.4	3.6	3.6	0.0	(D)	0.0
Paper, printing and support activities.....	322, 323	37	7.6	11.4	(S) 1.8	(D)	0.4	(D)	(D)	(D)
Petroleum and coal products.....	324	12	3.6	7.4	(S) 6.4	(D)	3.6	0.0	(D)	(D)
Chemicals.....	325	179	2.7	3.0	2.9	1.8	1.8	3.1	0.6	4.3
Basic chemicals.....	3251	58	9.0	10.8	17.0	17.2	17.4	43.3	(D)	0.2
Resin, synthetic rubber, fibers, and filament.....	3252	15	2.4	2.2	0.5	0.2	0.2	(D)	(D)	0.0
Pharmaceuticals and medicines.....	3254	45	1.4	3.9	1.6	(D)	0.5	0.0	0.0	(D)
Other chemicals.....	325 (minus 3251–52, 3254)	61	6.1	5.1	(S) 4.5	(D)	2.6	(D)	0.2	(D)
Plastics and rubber products.....	326	165	5.3	6.5	5.5	(D)	4.0	0.2	0.9	(D)
Nonmetallic mineral products.....	327	54	4.7	6.7	23.5	5.5	5.5	5.2	10.3	18.6
Primary metals.....	331	57	3.7	4.8	(S) 4.2	9.0	9.4	(D)	3.6	0.0
Fabricated metal products.....	332	165	5.4	5.5	7.4	5.0	5.2	3.4	28.5	1.5
Machinery.....	333	177	4.7	4.0	3.3	4.2	4.2	8.0	52.9	10.1
Computer and electronic products.....	334	385	3.5	3.6	(S) 1.6	0.9	1.0	0.6	4.2	0.9
Computers and peripheral equipment.....	3341	52	17.6	17.1	2.9	1.9	1.9	1.8	0.2	0.0
Communications equipment.....	3342	67	6.1	3.4	(S) 2.1	2.4	2.5	(D)	(D)	0.0
Semiconductor and other electronic components.....	3344	97	3.4	9.7	(S) 4.7	1.5	1.5	0.0	(D)	0.0
Navigational, measuring, electromedical, and control instruments.....	3345	133	4.5	2.2	1.9	1.4	2.1	1.2	22.6	1.0

See explanatory information and SOURCE at end of table.

Table B-2. Survey of Industrial Research and Development—relative standard error for survey estimates, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Number of R&D-performing companies ¹	Domestic net sales of R&D performers	Domestic employment of R&D performers	Number of FTE scientists and engineers	Total R&D	Company and other funds for R&D	Company-financed R&D performed outside of U.S.	Company-financed R&D contracted to outside organizations	Federal funds for R&D
Distribution by industry:										
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	36	7.7	4.9	1.1	0.8	0.6	(D)	5.6	57.6
Electrical equipment, appliances, and components.....	335	80	2.2	3.5	3.5	(D)	3.9	0.4	3.0	(D)
Transportation equipment.....	336	137	0.9	2.6	0.8	0.4	0.6	0.1	0.4	0.0
Motor vehicles, trailers, and parts.....	3361–63	86	1.1	4.2	1.2	(D)	0.7	(D)	(D)	(D)
Aerospace products and parts.....	3364	20	0.3	0.8	0.4	0.2	0.6	(D)	(D)	0.0
Other transportation equipment.....	336 (minus 3361–64)	31	3.1	3.1 (S)	3.3	(D)	4.9	(D)	(D)	(D)
Furniture and related products.....	337	70	54.8	5.5 (S)	6.3	4.2	4.2	(D)	(D)	0.0
Miscellaneous manufacturing.....	339	189	4.9	3.1	3.8	1.7	1.7	0.5	18.1	6.8
Medical equipment and supplies....	3391	101	5.9	3.2	4.2	(D)	1.8	(D)	17.2	(D)
Other miscellaneous manufacturing.....	339 (minus 3391)	88	8.3	6.8	8.5	(D)	5.2	(D)	58.8	(D)
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	--	--	--	--	--	--	--	--	--
Small manufacturing companies ²	Fewer than 50 employees	91	43.9	60.1	18.2	28.3	29.2	0.0	49.5	76.8
Nonmanufacturing.....	21–23, 42, 44–81	1,603	7.5	3.7	3.6	6.5	7.0	10.5	48.7	6.0
Mining, extraction, and support activities.....	21	34	3.8	2.9	1.4	0.7	0.7	0.0	(D)	57.0
Utilities.....	22	35	10.6	13.6	10.8	(D)	17.8	0.0	44.5	(D)
Construction.....	23	21	6.3	6.8	2.1	(D)	51.7	(D)	(D)	(D)
Trade.....	42, 44, 45	148	28.6	13.1	6.8	16.0	16.1	13.4	72.1	57.0
Transportation and warehousing.....	48, 49	19	12.8	3.0	44.1	(D)	16.7	0.0	55.5	(D)

See explanatory information and SOURCE at end of table.

Table B-2. Survey of Industrial Research and Development—relative standard error for survey estimates, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Number of R&D-performing companies ¹	Domestic net sales of R&D performers	Domestic employment of R&D performers	Number of FTE scientists and engineers	Total R&D	Company and other funds for R&D	Company-financed R&D performed outside of U.S.	Company-financed R&D contracted to outside organizations	Federal funds for R&D
Distribution by industry:										
Information.....	51	258	0.9	1.0	2.7	2.6	2.5	4.3	2.6	13.2
Publishing.....	511	206	4.3	3.1	3.3	2.8	2.7	7.1	9.5	53.8
Newspaper, periodical, book, and database.....	5111	13	4.9	5.3	27.8	19.7	19.7	(D)	0.0	0.0
Software.....	5112	193	5.4	3.8	3.2	2.8	2.7	(D)	9.7	53.8
Broadcasting and telecommunications.....	513	15	0.1	0.1	1.3	(S) 3.1	4.2	(D)	(D)	(D)
Radio and television broadcasting.....	5131	1	(D)	(D)	0.0	(D)	(D)	0.0	0.0	(D)
Telecommunications.....	5133	13	0.1	0.1	1.1	(D)	(D)	(D)	(D)	(D)
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	1	(D)	(D)	69.6	69.6	69.6	0.0	0.0	0.0
Other information.....	51 (minus 511, 513)	37	2.4	5.9	7.1	10.3	9.4	(D)	(D)	71.2
Finance, insurance, and real estate.....	52, 53	48	4.6	8.4	16.1	52.0	52.0	(D)	56.4	60.3
Professional, scientific, and technical services.....	54	910	3.4	4.3	3.6	3.8	4.6	34.3	12.2	4.8
Architectural, engineering, and related services.....	5413	159	3.7	4.1	(S) 6.5	16.1	23.7	83.0	64.2	9.0
Computer systems design and related services.....	5415	331	8.5	8.8	8.1	6.5	6.7	(D)	20.9	21.1
Scientific R&D services.....	5417	384	2.6	6.0	3.3	3.2	3.4	2.8	11.8	5.8
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	36	8.7	12.2	26.2	36.7	39.1	(D)	13.3	64.3
Management of companies and enterprises.....	55	13	11.4	16.8	15.3	13.9	13.4	(D)	66.8	94.4
Health care services.....	621–23	32	32.6	35.4	40.6	47.7	48.5	(D)	9.4	57.3

See explanatory information and SOURCE at end of table.

Table B-2. Survey of Industrial Research and Development—relative standard error for survey estimates, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Number of R&D-performing companies ¹	Domestic net sales of R&D performers	Domestic employment of R&D performers	Number of FTE scientists and engineers	Total R&D	Company and other funds for R&D	Company-financed R&D performed outside of U.S.	Company-financed R&D contracted to outside organizations	Federal funds for R&D
Distribution by industry:										
Other nonmanufacturing	56, 61, 624, 71, 72, 81	40	11.7	19.6	15.7	16.7	16.9	0.0	22.1	12.4
Small nonmanufacturing companies ²	Fewer than 15 employees	45	21.1	18.0	36.6	37.2	41.2	99.5	89.4	51.7
Distribution by size of company: [Number of employees]										
Total.....	(na)	3,583	3.0	2.8	1.6	2.5	2.8	3.2	33.0	1.9
5 to 24.....	(na)	233	14.2	9.4	22.9	23.9	26.9	93.5	63.0	31.6
25 to 49.....	(na)	214	16.3	11.4	13.8	17.9	18.5	58.5	64.3	19.5
50 to 99.....	(na)	358	12.8	9.6	12.4	24.2	26.0	69.3	29.3	18.2
100 to 249.....	(na)	566	12.3	9.4	6.7	7.2	7.3	71.5	11.8	25.5
250 to 499.....	(na)	467	34.8	11.6	5.5	5.3	5.5	14.4	12.2	8.9
500 to 999.....	(na)	441	12.7	11.6	9.5	14.0	14.8	21.4	12.3	0.2
1,000 to 4,999.....	(na)	800	15.8	13.9	3.1	13.1	13.5	2.5	76.2	3.6
5,000 to 9,999.....	(na)	233	4.7	4.5 (S)	0.1	0.1	0.1	0.0	2.0	0.0
10,000 to 24,999.....	(na)	157	3.7	6.7	0.4	0.2	0.2	0.0	5.0	0.0
25,000 or more.....	(na)	114	0.1	0.3 (S)	0.7	0.2	0.2	0.2	0.0	0.0

¹ The counts of R&D-performing companies in this table are equal to the sum of the counts of companies with reported or imputed R&D expenditures of "greater than or equal to \$5 million" plus companies with reported or imputed R&D expenditures of "less than \$5 million" in Table B-1. The relative standard error (RSE) estimates are based on reported and imputed data.

² The frame from which the statistical sample was selected was divided into two partitions based on total company employment. In the manufacturing sector, companies with employment of 50 or more were included in the large company partition. In the nonmanufacturing sector, companies with employment of 15 or more were included in the large company partition. Companies in the respective sectors with employment below these values, but with at least 5 employees, were included in the small company partition. The purpose of partitioning the sample this way was to reduce the variability in industry estimates largely attributed to the random year-to-year selection of small companies by industry and the high sampling weights that sometimes were assigned to them. Because of this, detailed industry statistics were possible only from the large company partition; detailed industry statistics from the small company partition were not possible. Statistics from the small company partition are shown separately and are included in manufacturing, nonmanufacturing, and all industries totals. For more information, see "frame creation" and "sample selection" in the technical notes in this section.

KEY: (D) = RSE is not calculated for a cell from which data have been withheld to avoid disclosing operations of individual companies.

(S) = RSE shown is calculated for a cell with imputation of more than 50 percent.

(--) = Indicates data not collected.

(na) = Not applicable.

NOTE: A description of the standard error of estimate is given in this section under "Sampling Stratification and Relative Standard Error Constraints." The percentage (or relative) standard errors in this table may be converted to standard errors of estimate by multiplying the percentages shown by the associated estimates. For example, the relative standard error of estimate for company-funded R&D performance by the wood products industry (NAICS 321) is shown as 3.6 percent, and the associated company-funded R&D estimate for this industry is shown as \$105 million in Table A-7. The standard error of estimate is 0.036 times 105 million or 3.8 million.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development 2000

Table B-3. **Survey of Industrial Research and Development—relative standard error for estimates of total R&D and percentage of estimates attributed to certainty companies, by state: 2000**

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State	Total R&D	Relative standard errors	Percent of estimate from certainties
United States, total.....	199,539	2.5	81.7
Alabama.....	607	16.5	74.1
Alaska.....	(S) 9	NA	100.0
Arizona.....	2,445	12.1	69.0
Arkansas.....	273	5.3	93.8
California.....	45,769	3.9	79.8
Colorado.....	3,140	7.1	79.1
Connecticut.....	(S) 4,371	13.3	81.0
Delaware.....	(S) 1,444	4.4	94.6
District of Columbia.....	112	34.8	61.9
Florida.....	3,212	8.2	76.8
Georgia.....	1,579	8.4	81.8
Hawaii.....	44	32.4	50.2
Idaho.....	1,338	2.8	94.4
Illinois.....	10,661	32.1	62.2
Indiana.....	(S) 2,668	5.7	84.8
Iowa.....	538	1.0	96.7
Kansas.....	(S) 1,140	2.2	94.8
Kentucky.....	582	11.0	79.9
Louisiana.....	126	26.4	64.4
Maine.....	201	14.2	79.9
Maryland.....	2,032	10.5	69.6
Massachusetts.....	9,863	1.8	91.3
Michigan.....	(S) 17,640	3.3	92.3
Minnesota.....	(S) 3,722	2.8	86.3
Mississippi.....	101	1.6	97.5
Missouri.....	1,893	9.6	73.6
Montana.....	(S) 28	6.8	86.3
Nebraska.....	199	39.6	36.1
Nevada.....	248	2.0	92.9
New Hampshire.....	586	6.1	84.3
New Jersey.....	12,062	13.3	73.4
New Mexico.....	(S) 1,158	4.5	92.9
New York.....	10,539	2.6	87.5
North Carolina.....	3,672	1.3	96.1
North Dakota.....	(S) 51	16.7	68.6

See explanatory information and SOURCE at end of table.

Table B-3. **Survey of Industrial Research and Development—relative standard error for estimates of total R&D and percentage of estimates attributed to certainty companies, by state: 2000**

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State		Total R&D	Relative standard errors	Percent of estimate from certainties
Ohio.....		5,962	7.0	79.3
Oklahoma.....		333	12.3	70.0
Oregon.....		1,651	9.0	63.0
Pennsylvania.....		7,873	3.1	87.9
Rhode Island.....	(S)	1,090	1.3	97.1
South Carolina.....		781	0.8	97.8
South Dakota.....		44	47.6	28.5
Tennessee.....	(S)	1,215	2.2	94.9
Texas.....		8,961	3.4	86.0
Utah.....		979	7.5	80.2
Vermont.....		396	9.2	84.6
Virginia.....		2,718	12.3	62.3
Washington.....	(S)	9,265	12.9	79.3
West Virginia.....		235	0.6	99.1
Wisconsin.....		1,981	2.5	88.7
Wyoming.....		7	NA	100.0
Undistributed funds.....	(S)	11,994	16.9	80.9

KEY: (S) = Indicates imputation of more than 50 percent.
NA = Not applicable

NOTE: A description of the standard error of estimate is given in this section under "Sampling Strata and Standard Error Estimates." The percentage (or relative) standard errors in this table may be converted to standard errors of estimate by multiplying the percentages shown by the associated estimates. For example, the relative error of estimate for United States, total is shown as 2.5 percent, and the associated R&D estimate is shown as \$199.5 million. The standard error of estimate is 0.025 times 199.5 million or 5 million.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development: 2000

companies” category were given weights up to a maximum of 250; company records classified in the remaining NAICS categories were given maximum weights of 100.

SURVEY FORMS

Two forms are used each year to collect data for the survey. Known large R&D performers are sent a detailed survey form, Form RD-1.³² The Form RD-1 requests data on sales or receipts, total employment, employment of scientists and engineers, expenditures for R&D performed within the company with Federal funds and with company and other funds, character of work (basic research, applied research, and development), company-sponsored R&D expenditures in foreign countries, R&D performed under contract by others, federally funded R&D by contracting agency, R&D costs by type of expense, domestic R&D expenditures by state, energy-related R&D and foreign R&D by country. Because companies receiving the Form RD-1 have participated in previous surveys, computer-imprinted data reported by the company for the previous year are supplied for reference. Companies are encouraged to revise or update this imprinted data if they have more current information, however prior-year statistics that previously have been published are revised only if large disparities are reported.³³

Small R&D performers and firms included in the sample for the first time are sent Form RD-1A. This form collects the same information as Form RD-1 except for five items: Federal R&D support to the firm by contracting agency, R&D costs by type of expense, domestic R&D expenditures by state, energy-related R&D, and foreign R&D by country. It also includes a screening item that allows respondents to indicate that they do not perform R&D. No prior-year information is made available since the majority of the companies that receive the Form RD-1A have not been surveyed in the previous year.

RECENT SURVEY FORM CONTENT CHANGES

Beginning with the 1997 survey, data on federally funded R&D performed under contract to others (or “contracted-out”) were collected to better measure the

amount of R&D performed both within and between companies. For earlier years, data were collected only on nonfederally funded contracted-out R&D.³⁴

A new item, R&D depreciation costs, was added to the 1998 Form RD-1. In prior years R&D depreciation was included in the “other costs” category of R&D expenditures. Also beginning with the 1998 survey, items used to collect detailed information on the allocation of R&D expenditures by field of science and engineering and by product class, and R&D expenditures for pollution abatement were eliminated. Further, the amount of detail requested for energy-related R&D was reduced. Item nonresponse on each of these items was unacceptably high relative to their response burden.

To control burden and continuity during the transition to NAICS, the 1999 and 2000 survey forms remained as they were for 1998.

NUMBER OF SURVEY FORMS SENT

Form RD-1 was mailed to companies that reported R&D expenditures of \$5 million dollars or more in the 1999 survey. Approximately 1,700 companies received Form RD-1 and approximately 23,100 received Form RD-1A. Both survey forms and the instructions provided to respondents are reproduced in section C, Survey Documents.

SURVEY NONRESPONSE

For various reasons, some firms did not choose to return the survey form or returned it with one or more blank items.³⁵ For some firms, internal accounting systems and procedures may not have allowed

³⁴Even though data on federally funded contracted-out R&D are collected, the tables based on the data tend to be “spotty.” That is, because federally funded contracted-out R&D is reported by so few companies, most of the resulting statistics arrayed by industry have to be suppressed because of confidentiality. Further, because of the sporadic nature of Federal funding of R&D in some industries, even in the aggregate, year-to-year changes can be quite large. Consequently, the tables containing the statistics are not published. Following are the results of recent data collections. In the 1997 table, the “all industries” total had to be suppressed, so no meaningful estimate could be made for that year. For 1998, the “all industries” total was \$4.3 billion; for 1999, the data were not tabulated; and for 2000, the “all industries” total was \$0.8 billion. We will continue to tabulate this item and report the aggregate estimate when possible.

³⁵For detailed discussions on the sources, control, and measurement error resulting from item nonresponse, see U.S. Bureau of the Census (1994b).

³²See U.S. Bureau of Census (1995).

³³See “Revisions to Historical and Immediate Prior-Year Statistics” later in this section.

quantification of specific expenditures. Others may have refused to answer any voluntary questions as a matter of company policy.³⁶

FOLLOW-UP FOR UNIT NONRESPONSE

The 2000 survey forms were mailed in March 2001. Recipients of Form RD-1A were asked to respond within 30 days, while Form RD-1 recipients were given 60 days. A follow-up form and letter were mailed to RD-1A recipients every thirty days if their completed survey form had not been received; a total of five follow-up mailings were conducted for delinquent RD-1A recipients.

A letter was mailed to Form RD-1 recipients thirty days after the initial mailing, reminding them that their completed survey forms were due within the next 30 days. A second form and reminder letter were mailed to Form RD-1 respondents after 60 days. Two additional follow-up mailings were sent to delinquent Form RD-1 recipients.

In addition to the mailings, telephone follow-up was used to encourage response from those firms ranked among the 300 largest R&D performers, based on total R&D expenditures reported in the previous survey. Table B-4 shows the number of companies in each industry or industry group that received a survey form and the percentage that responded to the survey.

If all attempts to get a response failed and no current-year information was reported, data for domestic sales, total employment, total R&D, and the number of R&D scientists and engineers were imputed as described in the next section.

IMPUTATION FOR UNIT AND ITEM NONRESPONSE

When respondents did not provide the requested information, estimates for the missing data were made using various methods. Specific rules governed imputation for missing data depending on the item being imputed. For some items (domestic sales, total employment, total R&D, and number of research scientists and engineers) missing current year data are always imputed.

Rates of change are applied to prior year data regardless of whether prior year data were reported or imputed. For other items (e.g., basic research, subcontracted R&D, and foreign R&D) missing current year data are imputed only if the company reported the item in either of the prior two years. A third type of imputation occurs when detail does not sum to the total (e.g., Federal R&D by agency). In this case if prior year detail is not imputed, then current year data are distributed based on the previous distribution pattern of the reporting unit. Otherwise, an industry average distribution is applied to the total to derive a value for each detail item. Rates of change are calculated by item within each NAICS category or industry. The calculations are based on weighted data for all companies that reported both variables. In the case of inter-item ratios (e.g., R&D to sales), calculations are based on data for all companies that reported both items in the current reporting period. For current-to-prior-year ratios (e.g., employment), calculations are based on data for all companies that reported that item in both years.³⁷

Outside sources of information are also used for imputing missing data. During the edit review process, analysts compare data reported to the Survey of Industrial Research and Development by publicly-owned companies with the company's report to the Securities and Exchange Commission (SEC). Data items matched include domestic sales, domestic employment, total or company-funded R&D, and in some cases, federally funded R&D. This comparison provides analysts a means to 1) potentially resolve inconsistencies between current and prior year data on the R&D survey, 2) impute missing data for specific items, and 3) ensure that companies are reporting comparable values in both reports. A second source for verifying or obtaining domestic employment and domestic sales data is the U.S. Census Bureau's Business Register. Data for these items are collected on economic census and annual survey forms. Table B-5 contains imputation rates for the principal survey items.

RESPONSE RATES AND MANDATORY/VOLUNTARY REPORTING

Current survey reporting requirements divide survey items into two groups: mandatory and voluntary. Response to four data items was mandatory; response to the remaining items was voluntary. The mandatory items were total R&D expenditures, Federal R&D funds,

³⁶All but four items—total R&D, Federal R&D, net sales, and total employment, which are included in the Census Bureau's annual mandatory statistical program—are voluntary. See further discussion under "Response Rates and Mandatory Versus Voluntary Reporting" later in this section.

³⁷For detailed descriptions and analyses of the imputation methods and algorithms used, see U.S. Bureau of the Census (1994c).

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
All industries.....	21–23, 31–33, 42, 44–81	24,844	21,066	84.8	15.6
Manufacturing.....	31–33	4,808	4,012	83.4	45.8
Food.....	311	131	113	86.3	62.0
Beverage and tobacco products.....	312	11	11	100.0	54.6
Textiles, apparel, and leather.....	313–16	244	192	78.7	40.1
Wood products.....	321	111	94	85.5	25.5
Paper, printing and support activities.....	322, 323	106	91	85.9	36.3
Petroleum and coal products.....	324	16	15	93.8	86.7
Chemicals.....	325	218	178	81.3	91.0
Basic chemicals.....	3251	62	55	88.7	94.6
Resin, synthetic rubber, fibers, and filament.....	3252	16	16	100.0	93.8
Pharmaceuticals and medicines.....	3254	51	40	76.9	100.0
Other chemicals.....	325 (minus 3251–52, 3254)	89	67	75.3	82.1
Plastics and rubber products.....	326	325	262	80.6	60.7
Nonmetallic mineral products.....	327	131	114	87.0	47.4
Primary metals.....	331	104	89	85.6	59.6
Fabricated metal products.....	332	337	297	88.1	53.9
Machinery.....	333	260	218	83.9	74.3
Computer and electronic products.....	334	529	414	78.3	79.5
Computers and peripheral equipment.....	3341	70	55	77.5	81.8
Communications equipment.....	3342	79	54	69.2	88.9
Semiconductor and other electronic components.....	3344	114	91	79.8	89.0
Navigational, measuring, electromedical, and control instruments.....	3345	159	131	82.4	90.8
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	107	83	77.6	43.4
Electrical equipment, appliances, and components.....	335	110	89	80.9	76.4
Transportation equipment.....	336	217	188	86.6	69.2
Motor vehicles, trailers, and parts.....	3361–63	137	119	86.9	68.9
Aerospace products and parts.....	3364	24	20	83.3	90.0
Other transportation equipment.....	336 (minus 3361–64)	56	49	87.5	61.2
Furniture and related products.....	337	180	168	88.4	41.1

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
Miscellaneous manufacturing.....	339	338	281	83.1	63.0
Medical equipment and supplies.....	3391	147	121	82.3	76.9
Other miscellaneous manufacturing.....	339 (minus 3391)	191	160	83.8	52.5
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	28	11	61.1	0.0
Small manufacturing companies ²	Fewer than 50 employees	1,412	1,187	84.1	7.7
Nonmanufacturing.....	21–23, 42, 44–81	20,036	17,054	85.1	8.5
Mining, extraction, and support activities.....	21	186	161	86.6	21.1
Utilities.....	22	65	58	89.2	60.3
Construction.....	23	2,055	1,798	87.5	1.2
Trade.....	42, 44, 45	3,040	2,653	87.3	4.9
Transportation and warehousing.....	48, 49	550	468	85.1	3.9
Information.....	51	745	590	79.2	38.0
Publishing.....	511	450	360	80.0	49.2
Newspaper, periodical, book, and database.....	5111	177	158	89.3	7.6
Software.....	5112	273	202	74.0	81.7
Broadcasting and telecommunications.....	513	129	102	79.1	12.8
Radio and television broadcasting.....	5131	34	30	88.2	3.3
Telecommunications.....	5133	72	55	76.4	20.0
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	23	17	73.9	5.9
Other information.....	51 (minus 511, 513)	166	128	77.1	26.6
Finance, insurance, and real estate.....	52, 53	870	765	87.9	4.8
Professional, scientific, and technical services.....	54	3,055	2,559	83.8	32.0
Architectural, engineering, and related services.....	5413	920	805	87.5	17.3
Computer systems design and related services.....	5415	837	633	75.6	47.7
Scientific R&D services.....	5417	475	393	82.7	87.5
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	823	728	88.5	4.8
Management of companies and enterprises.....	55	160	136	85.0	10.3
Health care services.....	621–23	1,024	911	89.0	3.5
Other nonmanufacturing	56, 61, 624, 71, 72, 81	2,707	2,222	82.1	1.6
Small nonmanufacturing companies ²	Fewer than 15 employees	5,579	4,733	84.8	0.9

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
COMPANIES THAT RECEIVED FORM RD-1					
All industries.....	21–23, 31–33, 42, 44–81	1,727	1,401	81.1	97.0
Manufacturing.....	31–33	934	776	83.1	97.9
Food.....	311	36	29	80.6	96.6
Beverage and tobacco products.....	312	4	4	100.0	100.0
Textiles, apparel, and leather.....	313–16	13	13	100.0	92.3
Wood products.....	321	4	2	50.0	150.0
Paper, printing and support activities.....	322, 323	30	26	86.7	96.2
Petroleum and coal products.....	324	8	8	100.0	100.0
Chemicals.....	325	142	123	86.6	99.2
Basic chemicals.....	3251	46	41	89.1	97.6
Resin, synthetic rubber, fibers, and filament.....	3252	14	14	100.0	100.0
Pharmaceuticals and medicines.....	3254	44	36	81.8	100.0
Other chemicals.....	325 (minus 3251–52, 3254)	38	32	84.2	100.0
Plastics and rubber products.....	326	46	40	87.0	97.5
Nonmetallic mineral products.....	327	11	10	90.9	100.0
Primary metals.....	331	21	17	81.0	94.1
Fabricated metal products.....	332	34	29	85.3	100.0
Machinery.....	333	112	96	85.7	97.9
Computer and electronic products.....	334	283	223	78.8	98.2
Computers and peripheral equipment.....	3341	36	29	80.6	96.6
Communications equipment.....	3342	58	39	67.2	97.4
Semiconductor and other electronic components.....	3344	90	72	80.0	97.2
Navigational, measuring, electromedical, and control instruments.....	3345	91	76	83.5	100.0
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	8	7	87.5	100.0
Electrical equipment, appliances, and components.....	335	51	40	78.4	97.5
Transportation equipment.....	336	76	66	86.8	98.5
Motor vehicles, trailers, and parts.....	3361–63	41	35	85.4	100.0
Aerospace products and parts.....	3364	19	16	84.2	100.0
Other transportation equipment.....	336 (minus 3361–64)	16	15	93.8	93.3
Furniture and related products.....	337	9	8	88.9	75.0

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
Miscellaneous manufacturing.....	339	52	41	78.9	100.0
Medical equipment and supplies.....	3391	38	30	79.0	100.0
Other miscellaneous manufacturing.....	339 (minus 3391)	14	11	78.6	100.0
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	0	0	0.0	0.0
Small manufacturing companies ²	Fewer than 50 employees	2	1	50.0	0.0
Nonmanufacturing.....	21–23, 42, 44–81	793	625	78.8	95.8
Mining, extraction, and support activities.....	21	14	13	92.9	100.0
Utilities.....	22	10	9	90.0	100.0
Construction.....	23	5	5	100.0	100.0
Trade.....	42, 44, 45	95	73	76.8	94.5
Transportation and warehousing.....	48, 49	4	4	100.0	75.0
Information.....	51	181	143	79.0	95.1
Publishing.....	511	148	116	78.4	98.3
Newspaper, periodical, book, and database.....	5111	5	4	80.0	100.0
Software.....	5112	143	112	78.3	98.2
Broadcasting and telecommunications.....	513	14	12	85.7	75.0
Radio and television broadcasting.....	5131	1	1	100.0	100.0
Telecommunications.....	5133	12	10	83.3	80.0
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	1	1	100.0	0.0
Other information.....	51 (minus 511, 513)	19	15	79.0	86.7
Finance, insurance, and real estate.....	52, 53	34	24	70.6	91.7
Professional, scientific, and technical services.....	54	422	333	78.9	97.3
Architectural, engineering, and related services.....	5413	64	46	71.9	95.7
Computer systems design and related services.....	5415	107	77	72.0	97.4
Scientific R&D services.....	5417	241	202	83.8	97.5
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	10	8	80.0	100.0
Management of companies and enterprises.....	55	2	2	100.0	100.0
Health care services.....	621–23	3	3	100.0	100.0
Other nonmanufacturing	56, 61, 624, 71, 72, 81	18	13	72.2	84.6
Small nonmanufacturing companies ²	Fewer than 15 employees	5	3	60.0	66.7

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
COMPANIES THAT RECEIVED FORM RD-1A					
All industries.....	21–23, 31–33, 42, 44–81	23,117	19,665	85.1	9.8
Manufacturing.....	31–33	3,874	3,236	83.5	33.3
Food.....	311	95	84	88.4	50.0
Beverage and tobacco products.....	312	7	7	100.0	28.6
Textiles, apparel, and leather.....	313–16	231	179	77.5	36.3
Wood products.....	321	106	92	86.8	22.8
Paper, printing and support activities.....	322, 323	76	65	85.5	12.3
Petroleum and coal products.....	324	8	7	87.5	71.4
Chemicals.....	325	77	55	71.4	72.7
Basic chemicals.....	3251	16	14	87.5	85.7
Resin, synthetic rubber, fibers, and filament.....	3252	2	2	100.0	50.0
Pharmaceuticals and medicines.....	3254	8	4	50.0	100.0
Other chemicals.....	325 (minus 3251–52, 3254)	51	35	68.6	65.7
Plastics and rubber products.....	326	279	222	79.6	54.1
Nonmetallic mineral products.....	327	120	104	86.7	42.3
Primary metals.....	331	83	72	86.8	51.4
Fabricated metal products.....	332	303	268	88.5	48.9
Machinery.....	333	148	122	82.4	55.7
Computer and electronic products.....	334	246	191	77.6	57.6
Computers and peripheral equipment.....	3341	35	26	74.3	65.4
Communications equipment.....	3342	20	15	75.0	66.7
Semiconductor and other electronic components.....	3344	24	19	79.2	57.9
Navigational, measuring, electromedical, and control instruments.....	3345	68	55	80.9	78.2
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	99	76	76.8	38.2
Electrical equipment, appliances, and components.....	335	59	49	83.1	59.2
Transportation equipment.....	336	141	122	86.5	53.3
Motor vehicles, trailers, and parts.....	3361–63	96	84	87.5	56.0
Aerospace products and parts.....	3364	5	4	80.0	50.0
Other transportation equipment.....	336 (minus 3361–64)	40	34	85.0	47.1
Furniture and related products.....	337	181	160	88.4	39.4

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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Industry and form received	NAICS codes	Number of companies that received a questionnaire ¹	Number of companies that responded to the survey	Percentage of companies that responded to the survey	Percentage of responding companies that reported R&D
Miscellaneous manufacturing.....	339	286	240	83.9	56.7
Medical equipment and supplies.....	3391	109	91	83.5	69.2
Other miscellaneous manufacturing.....	339 (minus 3391)	177	149	84.2	49.0
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	18	11	61	0
Small manufacturing companies ²	Fewer than 50 employees	1,410	1,186	84.1	7.7
Nonmanufacturing.....	21–23, 42, 44–81	19,243	16,429	85.4	5.1
Mining, extraction, and support activities.....	21	172	148	86.1	14.2
Utilities.....	22	55	49	89.1	53.1
Construction.....	23	2,050	1,793	87.5	1.0
Trade.....	42, 44, 45	2,945	2,580	87.6	2.4
Transportation and warehousing.....	48, 49	546	464	85.0	3.2
Information.....	51	564	447	79.3	19.7
Publishing.....	511	302	244	80.8	25.8
Newspaper, periodical, book, and database.....	5111	172	154	89.5	5.2
Software.....	5112	130	90	69.2	61.1
Broadcasting and telecommunications.....	513	115	90	78.3	4.4
Radio and television broadcasting.....	5131	33	29	87.9	0.0
Telecommunications.....	5133	60	45	75.0	6.7
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	22	16	72.7	6.3
Other information.....	51 (minus 511, 513)	147	113	76.9	18.6
Finance, insurance, and real estate.....	52, 53	836	741	88.6	2.0
Professional, scientific, and technical services.....	54	2,633	2,226	84.5	22.3
Architectural, engineering, and related services.....	5413	856	759	88.7	12.5
Computer systems design and related services.....	5415	730	556	76.2	40.8
Scientific R&D services.....	5417	234	191	81.6	77.0
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	813	720	88.6	3.8
Management of companies and enterprises.....	55	158	134	84.8	9.0
Health care services.....	621–23	1,021	908	88.9	3.2
Other nonmanufacturing	56, 61, 624, 71, 72, 81	2,689	2,209	82.2	1.1
Small nonmanufacturing companies ²	Fewer than 15 employees	5,574	4,730	84.9	0.9

See explanatory information and SOURCE at end of table.

Table B-4. **Survey of Industrial Research and Development—unit response rates-number and percentage of companies that responded to the survey and percentage of companies that performed R&D, by industry and type of survey form: 2000**

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¹ The "number of companies that received a questionnaire" is less than the number of "companies selected for the sample" in Table B-1 because some companies selected for the survey went out of business or were merged with other companies during the time between sample selection and survey mailout, that is, the sample frame was updated before actual mail-out took place. For more information, see "sample size" in the technical notes in this section.

² The frame from which the statistical sample was selected was divided into two partitions based on total company employment. In the manufacturing sector, companies with employment of 50 or more were included in the large company partition. In the nonmanufacturing sector, companies with employment of 15 or more were included in the large company partition. Companies in the respective sectors with employment below these values, but with at least 5 employees, were included in the small company partition. The purpose of partitioning the sample this way was to reduce the variability in industry estimates largely attributed to the random year-to-year selection of small companies by industry and the high sampling weights that sometimes were assigned to them. Because of this, detailed industry statistics were possible only from the large company partition; detailed industry statistics from the small company partition were not possible. Statistics from the small company partition are shown separately and are included in manufacturing, nonmanufacturing, and all industries totals. For more information, see "frame creation" and "sample selection" in the technical notes in this section.

KEY: (--) = Indicates data not collected.

NOTES: The calculation of the "percentage of companies that responded to the survey" was based on all companies that responded to the survey including those that reported they were out-of-scope, out-of-business, or had merged with another company. It excludes companies for which total R&D expenditure data were imputed. Mathematically, the percentage was calculated by dividing the number of companies that received a questionnaire (indicated in the previous column) into the number of companies that returned a response or questionnaire regardless of the data or information supplied in the response or on the questionnaire.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development: 2000

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Sales	Total employment	R&D scientists/ engineers	Total R&D			R&D costs by agency			
					Total	Company	Federal	DoD	NASA	DOE	Other agencies
[Percent]											
Distribution by industry:											
All industries.....	21–23, 31–33, 42, 44–81	13.5	13.8	37.6	10.7	10.4	23.3	52.2	61.4	39.3	50.0
Manufacturing.....	31–33	11.8	9.8	44.2	11.7	12.5	16.3	0.0	0.0	0.0	0.0
Food.....	311	14.4	11.5	29.7	(D)	12.1	(D)	0.0	0.0	0.0	0.0
Beverage and tobacco products.....	312	0.0	0.0	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Textiles, apparel, and leather.....	313–16	0.0	0.0	25.5	(D)	2.5	(D)	0.0	0.0	0.0	0.0
Wood products.....	321	0.0	0.0	72.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper, printing and support activities.....	322, 323	8.7	10.0	53.3	(D)	3.4	(D)	0.0	0.0	0.0	0.0
Petroleum and coal products.....	324	0.0	0.0	52.7	(D)	0.0	(D)	0.0	0.0	0.0	0.0
Chemicals.....	325	5.3	5.7	32.8	2.7	6.8	5.6	98.2	0.0	98.0	87.5
Basic chemicals.....	3251	8.0	6.0	24.0	6.8	6.7	10.3	0.0	0.0	0.0	0.0
Resin, synthetic rubber, fibers, and filament.....	3252	2.2	6.0	19.3	0.0	0.0	0.0	47.7	0.0	0.0	0.0
Pharmaceuticals and medicines.....	3254	1.5	4.1	25.9	(D)	8.5	(D)	0.0	0.0	0.0	0.0
Other chemicals.....	325 (minus 3251–52, 3254)	10.1	7.4	64.2	(D)	6.3	(D)	0.0	0.0	0.0	0.0
Plastics and rubber products.....	326	1.7	1.7	38.9	(D)	7.3	(D)	0.0	0.0	0.0	0.0
Nonmetallic mineral products.....	327	3.3	4.6	36.6	1.8	1.8	0.0	0.0	0.0	0.0	0.0
Primary metals.....	331	7.5	10.6	69.9	17.9	15.4	76.9	0.0	0.0	0.0	0.0
Fabricated metal products.....	332	3.7	3.4	31.0	4.4	5.1	0.0	0.0	0.0	0.0	0.0
Machinery.....	333	7.0	9.6	36.3	7.0	7.4	0.0	100.0	51.9	58.0	58.0
Computer and electronic products.....	334	14.4	9.4	59.4	14.1	15.2	1.3	22.2	68.8	0.0	58.5
Computers and peripheral equipment.....	3341	8.7	9.1	39.2	8.8	2.9	0.0	0.0	0.0	0.0	0.0
Communications equipment.....	3342	12.8	11.1	83.3	5.2	4.8	15.0	0.0	0.0	0.0	0.0
Semiconductor and other electronic components.....	3344	27.8	16.2	56.2	39.4	39.7	4.7	0.0	0.0	0.0	0.0
Navigational, measuring, electromedical, and control instruments.....	3345	1.4	1.6	43.6	1.3	2.0	0.0	0.0	0.0	0.0	0.0
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	13.5	13.3	28.1	9.6	9.7	0.0	0.0	0.0	0.0	0.0
Electrical equipment, appliances, and components.....	335	2.8	4.0	16.4	(D)	6.5	(D)	0.3	0.3	0.3	0.3
Transportation equipment.....	336	20.8	17.1	35.8	17.0	17.0	16.8	0.0	0.0	0.0	0.0
Motor vehicles, trailers, and parts.....	3361–63	16.9	10.3	34.1	(D)	13.3	(D)	5.4	5.4	5.4	5.4
Aerospace products and parts.....	3364	41.5	33.9	29.7	22.9	36.1	14.9	81.6	43.3	33.0	38.6
Other transportation equipment.....	336 (minus 3361–64)	4.2	11.0	69.6	(D)	7.2	43.9	100.0	100.0	0.0	100.0

See explanatory information and SOURCE at end of table.

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Sales	Total employment	R&D scientists/ engineers	Total R&D			R&D costs by agency			
					Total	Company	Federal	DoD	NASA	DOE	Other agencies
[Percent]											
Distribution by industry:											
Furniture and related products.....	337	5.1	4.0	50.5	33.2	33.2	0.0	0.0	0.0	0.0	0.0
Miscellaneous manufacturing.....	339	5.6	11.5	40.1	7.4	7.5	0.0	0.0	0.0	0.0	0.0
Medical equipment and supplies.....	3391	7.2	12.5	49.9	(D)	7.8	(D)	0.0	0.0	0.0	0.0
Other miscellaneous manufacturing.....	339 (minus 3391)	3.1	9.5	8.0	(D)	4.7	(D)	0.0	0.0	0.0	0.0
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	--	--	--	--	--	--	--	--	--	--
Small manufacturing companies ¹	Fewer than 50 employees	7.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonmanufacturing.....	21–23, 42, 44–81	16.4	20.4	28.5	9.0	7.2	34.3	0.0	0.0	0.0	0.0
Mining, extraction, and support activities.....	21	0.2	0.2	6.0	5.3	5.3	0.0	0.0	0.0	0.0	0.0
Utilities.....	22	0.0	0.0	11.6	(D)	0.0	(D)	0.0	0.0	0.0	0.0
Construction.....	23	0.0	0.0	0.4	(D)	0.0	(D)	0.0	0.0	0.0	0.0
Trade.....	42, 44, 45	6.2	8.8	26.2	1.9	1.9	0.7	0.0	0.0	0.0	0.0
Transportation and warehousing.....	48, 49	0.4	0.2	8.3	(D)	6.2	(D)	0.0	0.0	0.0	0.0
Information.....	51	29.2	32.8	23.2	10.6	8.9	62.4	0.0	0.0	0.0	0.0
Publishing.....	511	8.2	7.0	17.1	6.5	6.5	6.4	0.0	0.0	0.0	0.0
Newspaper, periodical, book, and database.....	5111	9.1	3.2	25.5	24.3	24.3	0.0	0.0	0.0	0.0	0.0
Software.....	5112	8.0	9.0	16.7	6.0	6.0	6.4	0.0	0.0	0.0	0.0
Broadcasting and telecommunications.....	513	39.0	46.0	89.0	55.4	43.6	87.1	0.0	0.0	0.0	0.0
Radio and television broadcasting.....	5131	(D)	(D)	(D)	(D)	(D)	(D)	0.0	0.0	0.0	0.0
Telecommunications.....	5133	37.3	43.5	(D)	(D)	(D)	(D)	0.0	0.0	0.0	0.0
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	(D)	(D)	0.0	0.0	0.0	(D)	0.0	0.0	0.0	0.0
Other information.....	51 (minus 511, 513)	6.6	10.2	9.2	6.7	6.9	0.0	0.0	0.0	0.0	0.0
Finance, insurance, and real estate.....	52, 53	26.0	38.8	31.9	13.8	13.8	0.0	0.0	0.0	0.0	0.0
Professional, scientific, and technical services.....	54	14.0	11.5	34.1	15.7	12.0	30.6	0.0	0.0	0.0	0.0
Architectural, engineering, and related services.....	5413	11.6	11.4	51.9	24.0	16.5	38.5	0.0	0.0	0.0	0.0
Computer systems design and related services.....	5415	5.5	4.8	23.4	8.2	8.7	7.3	0.0	0.0	0.0	0.0
Scientific R&D services.....	5417	35.6	28.5	32.0	17.0	12.9	29.4	0.0	0.0	0.0	0.0
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	1.5	5.5	36.1	10.6	9.1	30.6	0.0	0.0	0.0	0.0

See explanatory information and SOURCE at end of table.

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	Sales	Total employment	R&D scientists/ engineers	Total R&D			R&D costs by agency			
					Total	Company	Federal	DoD	NASA	DOE	Other agencies
[Percent]											
Distribution by industry:											
Management of companies and enterprises.....	55	0.0	0.0	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Health care services.....	621–23	0.2	0.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other nonmanufacturing	56, 61, 624, 71, 72, 81	13.5	27.9	33.8	25.0	25.6	0.0	0.0	0.0	0.0	0.0
Small nonmanufacturing companies ¹	Fewer than 15 employees	6.2	0.2	33.0	2.1	2.3	0.0	0.0	0.0	0.0	0.0
Distribution by size of company: [Number of employees]											
Total.....	(na)	13.5	13.8	37.6	10.7	10.4	23.3	0.0	0.0	0.0	0.0
5 to 24.....	(na)	13.5	1.0	26.9	2.3	2.6	0.2	0.0	0.0	0.0	0.0
25 to 49.....	(na)	6.8	0.4	6.7	2.5	2.4	4.6	0.0	0.0	0.0	0.0
50 to 99.....	(na)	3.8	1.8	7.7	3.8	3.2	10.6	0.0	0.0	0.0	0.0
100 to 249.....	(na)	2.9	3.8	20.5	9.2	9.4	7.4	0.0	0.0	0.0	0.0
250 to 499.....	(na)	4.7	4.7	20.9	10.4	10.5	13.6	0.0	0.0	0.0	0.0
500 to 999.....	(na)	6.1	6.1	31.5	15.4	15.3	17.6	0.0	0.0	0.0	0.0
1,000 to 4,999.....	(na)	8.2	8.3	30.7	10.7	9.7	47.9	0.0	0.0	0.0	0.0
5,000 to 9,999.....	(na)	9.2	12.4	50.3	9.6	8.2	2.3	0.0	0.0	0.0	0.0
10,000 to 24,999.....	(na)	3.9	5.7	31.8	2.0	4.4	33.7	0.0	0.0	0.0	0.0
25,000 or more.....	(na)	22.5	23.6	56.1	16.8	16.5	18.2	0.0	0.0	0.0	0.0

See explanatory information and SOURCE at end of table.

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	R&D by type of cost				Company R&D		Energy R&D
		Wages	Materials	Depreciation	Other costs	Contracted out R&D	Foreign R&D	
		[Percent]						
Distribution by industry:								
All industries.....	21–23, 31–33, 42, 44–81	54.7	56.5	11.5	58.5	6.9	3.2	45.8
Manufacturing.....	31–33	57.5	55.6	15.9	60.8	12.3	2.9	(D)
Food.....	311	62.3	62.4	2.2	49.9	0.0	59.0	0.0
Beverage and tobacco products.....	312	(D)	(D)	(D)	13.1	(D)	(D)	0.0
Textiles, apparel, and leather.....	313–16	15.7	16.4	0.0	24.5	0.0	(D)	0.0
Wood products.....	321	79.1	(D)	(D)	(D)	(D)	0.0	0.0
Paper, printing and support activities.....	322, 323	60.2	67.6	0.0	40.2	(D)	(D)	0.0
Petroleum and coal products.....	324	75.6	60.3	0.0	58.9	(D)	0.0	0.0
Chemicals.....	325	35.4	30.4	6.7	48.8	13.6	2.0	(D)
Basic chemicals.....	3251	53.0	49.7	41.7	51.9	(D)	15.2	0.0
Resin, synthetic rubber, fibers, and filament.....	3252	24.2	(D)	(D)	21.3	(D)	(D)	0.0
Pharmaceuticals and medicines.....	3254	12.8	9.9	0.5	47.1	14.2	1.0	0.0
Other chemicals.....	325 (minus 3251–52, 3254)	80.2	81.8	59.3	80.9	1.4	(D)	0.0
Plastics and rubber products.....	326	65.5	43.2	2.7	68.3	0.0	0.5	0.0
Nonmetallic mineral products.....	327	29.2	12.9	(D)	(D)	0.0	0.0	0.0
Primary metals.....	331	31.6	63.1	64.5	70.8	26.7	(D)	0.0
Fabricated metal products.....	332	73.0	73.8	21.5	78.3	0.0	6.7	0.0
Machinery.....	333	36.0	35.2	8.4	34.8	0.0	9.6	(D)
Computer and electronic products.....	334	71.3	74.9	16.1	67.3	22.5	4.4	(D)
Computers and peripheral equipment.....	3341	55.0	57.9	10.3	23.6	5.0	1.9	0.0
Communications equipment.....	3342	92.8	94.1	15.0	89.5	(D)	(D)	0.0
Semiconductor and other electronic components...	3344	62.8	51.8	18.1	75.2	(D)	4.0	0.0
Navigational, measuring, electromedical, and control instruments.....	3345	45.8	58.1	13.0	70.3	0.0	0.4	0.0
Other computer and electronic products.....	334 (minus 3341–42, 3344–45)	8.7	4.6	0.0	28.2	0.0	(D)	0.0
Electrical equipment, appliances, and components.....	335	20.7	14.5	16.7	22.9	0.0	3.6	(D)
Transportation equipment.....	336	61.7	55.4	31.6	79.0	1.8	0.1	28.1
Motor vehicles, trailers, and parts.....	3361–63	61.0	53.7	37.6	65.6	(D)	(D)	0.0
Aerospace products and parts.....	3364	60.1	58.0	(D)	(D)	(D)	(D)	0.0
Other transportation equipment.....	336 (minus 3361–64)	79.6	76.3	72.3	89.0	(D)	(D)	0.0

See explanatory information and SOURCE at end of table.

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	R&D by type of cost				Company R&D		Energy R&D
		Wages	Materials	Depreciation	Other costs	Contracted out R&D	Foreign R&D	
		[Percent]						
Distribution by industry:								
Furniture and related products.....	337	77.5	(D)	(D)	83.4	(D)	(D)	0.0
Miscellaneous manufacturing.....	339	39.4	36.9	1.9	23.2	2.1	1.9	0.0
Medical equipment and supplies.....	3391	43.4	38.4	2.8	22.8	2.6	(D)	0.0
Other miscellaneous manufacturing.....	339 (minus 3391)	29.6	32.2	0.0	31.3	0.0	(D)	0.0
Other manufacturing	31–33 (minus 311–16, 321–27, 331–37, 339)	--	--	--	--	--	--	--
Small manufacturing companies ¹	Fewer than 50 employees	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonmanufacturing.....	21–23, 42, 44–81	50.1	59.2	5.0	50.2	4.8	3.9	0.0
Mining, extraction, and support activities.....	21	7.3	45.4	0.0	10.3	(D)	2.4	(D)
Utilities.....	22	37.5	37.0	0.0	36.3	0.0	0.0	0.0
Construction.....	23	69.9	0.0	0.0	60.3	(D)	(D)	0.0
Trade.....	42, 44, 45	48.1	67.6	0.3	43.7	0.0	0.4	0.0
Transportation and warehousing.....	48, 49	46.7	46.7	0.0	46.7	0.0	0.0	0.0
Information.....	51	52.6	61.3	10.6	55.8	43.8	2.2	0.0
Publishing.....	511	55.5	56.7	10.2	56.9	11.0	3.3	0.0
Newspaper, periodical, book, and database.....	5111	38.7	0.0	(D)	(D)	20.7	(D)	0.0
Software.....	5112	55.8	58.1	11.9	56.8	10.7	(D)	0.0
Broadcasting and telecommunications.....	513	89.1	88.5	9.8	84.2	(D)	0.0	0.0
Radio and television broadcasting.....	5131	0.0	0.0	100.0	0.0	0.0	0.0	
Telecommunications.....	5133	86.3	88.5	9.8	77.5	(D)	(D)	0.0
Other broadcasting and telecommunications.....	513 (minus 5131, 5133)	0.0	0.0	0.0	0.0	0.0	0.0	
Other information.....	51 (minus 511, 513)	11.0	25.7	33.0	24.2	(D)	(D)	0.0
Finance, insurance, and real estate.....	52, 53	57.0	77.3	(D)	(D)	12.3	(D)	0.0
Professional, scientific, and technical services.....	54	50.2	45.3	7.9	52.0	6.7	7.8	0.0
Architectural, engineering, and related services.....	5413	53.7	49.6	4.8	57.5	2.1	6.9	0.0
Computer systems design and related services.....	5415	45.2	47.8	8.7	37.2	2.1	(D)	0.0
Scientific R&D services.....	5417	50.2	43.9	8.5	52.7	8.2	4.7	0.0
Other professional, scientific, and technical services.....	54 (minus 5413, 5415, 5417)	69.7	61.6	(D)	(D)	0.0	(D)	0.0

See explanatory information and SOURCE at end of table.

Table B-5. Survey of Industrial Research and Development—imputation rates for survey items, by industry and size of company: 2000

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Industry and size of company	NAICS codes	R&D by type of cost				Company R&D		Energy R&D
		Wages	Materials	Depreciation	Other costs	Contracted out R&D	Foreign R&D	
		[Percent]						
Distribution by industry:								
Management of companies and enterprises.....	55	(D)	(D)	(D)	(D)	0.0	(D)	0.0
Health care services.....	621–23	0.0	0.0	0.0	0.0	0.0	(D)	0.0
Other nonmanufacturing	56, 61, 624, 71, 72, 81	53.3	46.5	0.0	38.7	0.0	79.5	0.0
Small nonmanufacturing companies ¹	Fewer than 15 employees	30.7	(D)	(D)	24.2	0.0	0.0	0.0
Distribution by size of company:								
[Number of employees]								
Total.....	(na)	54.7	56.5	11.5	58.5	6.9	3.2	45.8
5 to 24.....	(na)	80.7	76.7	0.0	65.1	0.0	0.0	0.0
25 to 49.....	(na)	57.9	58.6	0.0	48.2	0.9	0.0	0.0
50 to 99.....	(na)	42.3	36.8	8.7	40.2	6.9	0.2	(D)
100 to 249.....	(na)	50.1	31.9	20.0	47.8	14.3	5.7	(D)
250 to 499.....	(na)	46.7	50.0	14.8	40.4	1.8	14.0	(D)
500 to 999.....	(na)	41.5	31.8	22.0	43.4	23.0	5.5	(D)
1,000 to 4,999.....	(na)	35.1	41.9	13.0	40.8	1.1	9.2	23.5
5,000 to 9,999.....	(na)	49.2	51.6	10.3	74.4	7.5	3.7	2.1
10,000 to 24,999.....	(na)	63.0	51.7	6.6	51.1	18.7	2.1	0.0
25,000 or more.....	(na)	66.4	64.8	7.4	68.3	15.5	0.6	15.6

¹ The frame from which the statistical sample was selected was divided into two partitions based on total company employment. In the manufacturing sector, companies with employment of 50 or more were included in the large company partition. In the nonmanufacturing sector, companies with employment of 15 or more were included in the large company partition. Companies in the respective sectors with employment below these values, but with at least 5 employees, were included in the small company partition. The purpose of partitioning the sample this way was to reduce the variability in industry estimates largely attributed to the random year-to-year selection of small companies by industry and the high sampling weights that sometimes were assigned to them. Because of this, detailed industry statistics were possible only from the large company partition; detailed industry statistics from the small company partition were not possible. Statistics from the small company partition are shown separately and are included in manufacturing, nonmanufacturing, and all industries totals. For more information, see "frame creation" and "sample selection" in the technical notes in this section.

KEY: (D) = Imputation rate is not calculated for a cell from which data have been withheld to avoid disclosing operations of individual companies.
 (--) = Indicates data not collected.
 (na) = Not applicable.

NOTES: The figures in this table represent the percentage of the value in a given table cell in the Section A tables that has been imputed. In those tables, cells for which more than 50 percent of the value is imputed are flagged with an "(S)."

Cells in this table that contain "0.0" indicate that no imputation was performed or, if performed, imputation accounted for less than 0.1 percent of the estimate for the indicated item.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development: 2000

net sales, and total employment. During the 1990 survey cycle, NSF conducted a test of the effect of reporting on a completely voluntary basis to determine if combining both mandatory and voluntary items on one survey form influences response rates. For this test, the 1990 sample was divided into two panels of approximately equal size. One panel, the mandatory panel, was asked to report as usual on four mandatory items with the remainder voluntary; and the other panel was asked to report all items on a completely voluntary basis. The result of the test was a decrease in the overall survey response rate to 80 percent from levels of 88 percent in 1989 and 89 percent in 1988. The response rates for the mandatory and voluntary panels were 89 percent and 69 percent, respectively. Detailed results of the test were published in *Research and Development in Industry: 1990*. For firms that reported R&D expenditures in 2000, table B-6 shows the percentage that also reported data for other selected items.

CHARACTER OF WORK ESTIMATES

Response to questions about character of work (basic research, applied research, and development) declined in the mid-1980s, and, as a result, imputation rates increased. The general imputation procedure described above became increasingly dependent upon information imputed in prior years, thereby distancing current year estimates from any reported information. Because of the increasing dependence on imputed data, NSF chose not to publish character of work estimates in 1986. The imputation procedure used to develop these estimates was revised in 1987 for use with later data and differs from the general imputation approach. The new method calculated the character of work distribution for a nonresponding firm only if that firm reported a distribution within a 5-year period, extending from 2 years before to 2 years after the year requiring imputation. Imputation for a given year was initially performed in the year the data were collected and was based on a character of work distribution reported in either of the 2 previous years, if any. It was again performed using new data collected in the next 2 years. If reported data followed no previously imputed or reported data, previous period estimates were inserted based on the currently reported information. Similarly, if reported data did not follow 2 years of imputed data, the 2 years of previously imputed data were removed. Thus, character of work estimates were revised as newly reported information became available and were not final for 2 years following their initial publication.

Beginning with 1995, previously estimated values were not removed for firms that did not report in the third year, nor were estimates made for the 2 previous years for firms reporting after 2 years of nonresponse. This process was changed because, in the prior period, revisions were minimal. Estimates continued to be made for 2 consecutive years of nonresponse and discontinued if the firm did not report character of work in the third year. If no reported data were available for a firm, character of work estimates were not imputed. As a consequence, only a portion of the total estimated R&D expenditures were distributed at the firm level. Those expenditures not meeting the requirements of the new imputation methodology were placed in a “not distributed” category.

NSF’s objective in conducting the survey has always been to provide estimates for the entire population of firms performing R&D in the United States. However, the revised imputation procedure would no longer produce such estimates because of the “not distributed” component. A baseline estimation method thus was developed to allocate the “not distributed” amounts among the character of work components. In the baseline estimation method, the “not distributed” expenditures were allocated by industry group to basic research, applied research, and development categories using the percentage splits in the distributed category for that industry. The allocation was done at the lowest level of published industry detail only; higher levels were derived by aggregation, just as national totals were derived by aggregation of individual industry estimates, and result in higher performance shares for basic and applied research and lower estimates for development’s share than would have been calculated using the previous method.

Using data collected during the 1999 and 2000 cycles of the survey, reporting anomalies for the character of work survey items, especially for basic research, were investigated. It was discovered that a significant number of large companies known to develop and manufacture products reported all of their R&D as basic research. This phenomenon is not logical and prompted a renewed effort to strengthen character of work estimates produced from the survey. Further identification of anomalous reporting patterns is underway and research is being pursued to determine appropriate methods of dealing with the anomalies. Publication of character of work distributions of R&D has been suspended until the research is complete and recommendations have been made,

Table B-6. Survey of Industrial Research and Development—percentage of R&D-performing companies that reported non-zero data for major survey items: 2000

Survey Item	Form RD-1 ^{1,2}	Form RD-1A ^{1,2}
Sales ³	97.4	96.9
Total employment ³	98.3	99.2
Scientist and engineers.....	75.9	86.0
Federal R&D ^{3,4}	99.9	99.8
Department of Defense.....	5.5	(NA)
NASA.....	2.6	(NA)
Department of Energy.....	1.9	(NA)
Other Federal agencies.....	6.2	(NA)
Company R&D ⁴	99.9	99.8
Contracted out R&D.....	17.3	14.1
Foreign R&D.....	30.6	7.3
Total R&D ³	100.0	100.0
Wages and salaries.....	66.1	(NA)
Materials and supplies.....	59.3	(NA)
R&D depreciation.....	41.8	(NA)
Other costs by type of expense.....	60.2	(NA)
Energy R&D	3.1	(NA)

¹ Percentages are based on reported data for companies that reported total R&D expenditures. Imputed data are not included. Companies that reported they were out-of-scope, out-of-business, merged with another company, or had no R&D expenditures for 2000 were excluded from the calculations.

² For descriptions of the survey forms, see technical notes in this section.

³ Response to four data items on the questionnaires, sales, total employment, Federal R&D, and total R&D, was mandatory. Response to all other items was voluntary.

⁴ Item response for "Federal R&D" and for "Company R&D" are considered together; companies that reported "Total R&D" and either of these expenditures implicitly reported both company and Federal R&D, since these two items sum to total R&D.

KEY: (NA) = Not available.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development: 2000

consequently tables containing basic research, applied research, and development estimates do not appear in this report.

STATE ESTIMATES

Form RD-1 requests a distribution of the total cost of R&D among the state(s) where the R&D was performed. Prior to the 1999 survey, an independent source, the *Directory of American Research and Development*, published by the Data Base Publishing Group of the R. R. Bowker Company was used in conjunction with previous survey results to estimate R&D expenditures by state for companies that did not provide this information. The information on scientists and engineers published in the directory was used as a proxy indicator of

the proportion of R&D expenditures within each state. R&D expenditures by state were estimated by applying the distribution of scientists and engineers by state from the directory to total R&D expenditures for these companies. These estimates were included with reported survey data to arrive at published estimates of R&D expenditures for each state.

The practice of using outside information to formulate or adjust estimates of R&D expenditures for each state has been discontinued because a suitable source for supporting information is no longer available.³⁸ State estimates resulting from the 1999 and 2000 surveys are based solely on respondent reports and information internal to the survey.

³⁸The Bowker *Directory*, last available for 1997, is no longer being published.

COMPARABILITY OF STATISTICS

This section summarizes survey improvements, enhancements, and changes in procedures and practices that may have affected the comparability of statistics produced from the Survey of Industrial Research and Development over time and with other statistical series.³⁹

INDUSTRY CLASSIFICATION SYSTEM

Beginning with the 1999 cycle of the survey, industry statistics are published using the North American Industrial Classification System (NAICS). The ongoing development of NAICS has been a joint effort of statistical agencies in Canada, Mexico, and the United States. The system replaced the Standard Industrial Classification (1980) of Canada, the Mexican Classification of Activities and Products (1994), and Standard Industrial Classification (SIC, 1987) of the United States.⁴⁰ NAICS was designed to provide a production-oriented system under which economic units with similar production processes are classified in the same industry. NAICS was developed with special attention to classifications for new and emerging industries, service industries, and industries that produce advanced technologies. NAICS not only eases comparability of information about the economies of the three North American countries, but it also increases comparability with the two-digit level of the United Nations' International Standard Industrial Classification (ISIC) system. Important for the Survey of Industrial Research and Development is the creation of several new classifications that cover major performers of R&D in the U.S. Among manufacturers, the computer and electronic products classification (NAICS 334) includes makers of computers and peripherals, semiconductors, and navigational and electromedical instruments. Among nonmanufacturing industries are information (NAICS 51) and professional, scientific, and technical services (NAICS 54). Information includes publishing, both paper and electronic, broadcasting, and telecommunications. Professional, scientific, and technical services includes a variety of industries. Of specific importance for the survey are engineering and scientific R&D service industries.

Effects of NAICS on Survey Statistics. The change of industry classification system affects most of the detailed statistical tables produced from the survey. In this report, some tables which contain industry statistics from the 1997 and 1998 cycles of the survey, previously classified using the SIC system, have been reclassified using the new NAICS codes. This has been done to provide a bridge for users who want to make year-to-year comparisons below the aggregate level.

COMPANY SIZE CLASSIFICATIONS

Beginning with the 1999 cycle of the survey, the number of company size categories used to classify survey statistics was increased. The original 6 categories were expanded to 10 to emphasize the role of small companies in R&D performance. During 1998, companies with fewer than 500 employees spent \$30.2 billion on industrial R&D performed in the United States. During 1999, they spent \$34.1 billion.⁴¹ Because of the addition of the new size classifications, we can say that of the \$34.1 billion, 21 percent (\$7.0 billion) was spent by the smallest companies (those with at least 5 but fewer than 25 employees). Further, again because of the new size classifications, the 1999 statistics show that there was more growth in the amount of R&D performed by smaller companies than in the amount performed by larger companies. The more detailed business size information also facilitates better international comparisons. Generally, statistics produced by foreign countries that measure their industrial R&D enterprise are reported with more detailed company size classifications at the lower end of the scale than U.S. industrial R&D statistics traditionally have been.⁴² The new classifications of the U.S. statistics enable more direct comparisons with other countries' statistics.

REVISIONS TO HISTORICAL AND IMMEDIATE PRIOR YEAR STATISTICS

Revisions to historical statistics usually have been made because of changes in the industry classification of companies caused by changes in payroll composition

³⁹See also NSF (2002a) and U.S. Bureau of the Census (1995).

⁴⁰For a detailed comparison of NAICS to the Standard Industrial Classification (1987) of the United States, visit <http://www.census.gov/ipeds/www/naics.html>.

⁴¹NSF (2001).

⁴²For more information, visit the Organisation for Economic Co-operation and Development (OECD) website at <http://www.oecd.org>.

detected when a new sample was drawn. Various methodologies have been adopted over the years to revise, or backcast, the data when revisions to historical statistics have become necessary. Documented revisions to the historical statistics from post-1967 surveys through 1992 are summarized in NSF (1994) and in annual reports for subsequent surveys. Detailed descriptions of the specific revisions made to the statistics from pre-1967 surveys are scarce, but U.S. Bureau of the Census (1995) summarizes some of the major revisions.

Changes to reported data can come from three sources: respondents, analysts involved in survey and statistical processing, and the industry reclassification process. Prior to 1995, routine revisions were made to prior year statistics based on information from all three sources. Consequently, results from the current year survey were used not only to develop current year statistics, but also to revise immediate prior year statistics. Beginning with the 1995 survey, this practice was discontinued. The reasons for discontinuation of this practice were annual sampling, continual strengthening of sampling methodology, and improvements in data verification, processing, and nonresponse follow-up. Moreover, it was not clear that respondents or those who processed the survey results had any better information a year after the data were first reported. Thus, it was determined that routinely revising published survey statistics increased the potential for error and often confused users of the statistics. Revisions are now made to historical and immediate prior year statistics only if substantive errors are discovered.

For 1999, an error in the sample frame caused one very large company (based on payroll) to be selected for the sample and its statistical record to be assigned a large weight (see “Frame Creation” and “Weighting and Maximum Weights” above). Because the company’s record had received a large weight during 1999 sampling, the company was selected with certainty for the 2000 sample and assigned a weight of one (see “Identifying Certainty Companies” above). This sampling artifact caused an abnormally large decrease in the company’s data, especially for sales and employment,⁴³ when comparing the 2000 statistics with the statistics originally published for 1999. The weight in the company’s record in the 1999 statistical file was corrected and revised 1999 statistics are included in the tables in this report.

⁴³R&D estimates for the company also were affected, however, the amount of R&D reported was relatively small, even after weighting.

YEAR-TO-YEAR CHANGES

Comparability from year to year may be affected by new sample design, annual sample selection, and industry shifts.

SAMPLE DESIGN

By far the most profound influence on statistics from recent surveys occurred when the new sample design for the 1992 survey was introduced. Revisions to the 1991 statistics were dramatic (see *Research and Development in Industry: 1992* for a detailed discussion). While the allocation of the sample was changed somewhat, the sample designs used for subsequent surveys were comparable to the 1992 sample design in terms of size and coverage.

ANNUAL SAMPLE SELECTION

With the introduction of annual sampling in 1992, more year-to-year change has resulted than when survey panels were used. There are two reasons why this was so. First, changes in classification of companies not surveyed are not reflected in the year-to-year movement. Prior to annual sampling, a wedging operation—which was performed when a new sample was selected—was a means of adjusting the data series to account for the changes in classification that occurred in the frame (see the discussion on wedging later under “Time Series Analyses”). Second, yearly correlation of R&D data is lost when independent samples are drawn each year.

INDUSTRY SHIFTS

The industry classification of companies is redefined each year with the creation of the sampling frame. By redefining the frame, the sample reflects current distributions of companies by size and industry. A company may move from one industry to another because of either changes in its payroll composition, which is used to determine the industry classification code (see previous discussion under “Frame Creation”); changes in the industry classification system itself; or changes in the way the industry classification code was assigned or revised during survey processing.

A company’s payroll composition can change because of the growth or decline of product or service lines, the merger of two or more companies, the acquisition of one company by another, divestitures, or the formation of conglomerates. Although an unlikely occurrence, a company’s industry designation could be reclassified

yearly with the introduction of annual sampling. The result is that a downward movement in R&D expenditures in one industry is balanced by an upward movement in another industry from one year to the next.

From time to time, the industry coding system used by Federal agencies that publish industry statistics is changed or revised to reflect the changing composition of U.S. and North American industry. For statistics developed for 1988–91 from the 1988–91 surveys, companies retained the Standard Industrial Classification (SIC) codes assigned for the 1987 sample. These classifications were based on the 1977 SIC system. Since the last major revision of the SIC system was in 1987, this revision was used to classify companies in the 1992–98 surveys. As discussed above, the industrial classification system has been completely changed and, beginning with the 1999 cycle of the survey, the North American Industrial Classification System (NAICS) is now used.

The method used to classify firms during survey processing was revised slightly in 1992. Research has shown that the impact on individual industry estimates was minor.⁴⁴ The current method used to classify firms was discussed previously under “Frame Creation.” Methods used for past surveys are discussed in U.S. Bureau of the Census (1995).

CAPTURING SMALL AND NONMANUFACTURING R&D PERFORMERS⁴⁵

Before the 1992 survey, the sample of firms surveyed was selected at irregular intervals.⁴⁶ In intervening years, a panel of the largest firms known to perform R&D was surveyed. For example, a sample of about 14,000 firms was selected for the 1987 survey. For the 1988–91 studies, about 1,700 of these firms were resurveyed annually; the other firms did not receive survey forms, and their R&D data were estimated. This sample design was adequate during the survey’s early years because R&D performance was concentrated in relatively few manufacturing industries. However, as more and more firms began entering the R&D arena, the old sample design

proved increasingly deficient because it did not capture births of new R&D-performing firms. The entry of fledgling R&D performers into the marketplace was completely missed during panel years. Additionally, beginning in the early 1970s, the need for more detailed R&D information for nonmanufacturing industries was recognized. At that time, the broad industry classifications “miscellaneous business services” and “miscellaneous services” were added to the list of industry groups for which statistics were published. By 1975, about 3 percent of total R&D was performed by firms in nonmanufacturing industries.

During the mid-1980s, there was evidence that a significant amount of R&D was being conducted by an increasing number of companies classified among the nonmanufacturing industries. Again the number of industries used to develop the statistics for nonmanufacturers was increased. Consequently, the annual reports in this series for 1987–91 included separate R&D estimates for firms in the communication, utility, engineering, architectural, research, development, testing, computer programming, and data processing service industries; hospitals; and medical labs. Approximately 9 percent of the estimated industrial R&D performance during 1987 was undertaken by nonmanufacturing firms.

After the list of industries for which statistics were published was expanded, it became clear that the sample design itself should be changed to reflect the widening population of R&D performers among firms in the nonmanufacturing industries⁴⁷ and small firms in all industries so as to account better for births of R&D-performing firms and to produce more reliable statistics.

⁴⁴The effects of changes in the way companies were classified during survey processing are discussed in detail in U.S. Bureau of the Census (1994a and 1994e).

⁴⁵See also NSF (1994, 1995, and 1996a).

⁴⁶Until 1967, samples were selected every 5 years. Subsequent samples were selected for 1971, 1976, 1981, and 1987.

⁴⁷For the 1992 survey, 25 new nonmanufacturing industry and industry groups were added to the sample frame: agricultural services (SIC 07); fishing, hunting, and trapping (SIC 09); wholesale trade–nondurables (SIC 51); stationery and office supply stores (SIC 5112); industrial and personal service paper (SIC 5113); groceries and related products (SIC 514); chemicals and allied products (SIC 516); miscellaneous nondurable goods (SIC 519); home furniture, furnishings, and equipment stores (SIC 57); radio, TV, consumer electronics, and music stores (SIC 573); eating and drinking places (SIC 581); miscellaneous retail (SIC 59); nonstore retailers (SIC 596); real estate (SIC 65); holding and other investment offices (SIC 67); hotels, rooming houses, camps, and other lodging places (SIC 70); automotive repair, services, and parking (SIC 75); miscellaneous repair services (SIC 76); amusement and recreation services (SIC 79); health services (SIC 80); offices and clinics of medical doctors (SIC 801); offices and clinics of other health practitioners (SIC 804); miscellaneous health and allied services not elsewhere classified (SIC 809); engineering, accounting, research, management, and related services (SIC 87); and management and public relations services (SIC 874).

Beginning with the 1992 survey, NSF decided to (1) draw new samples with broader coverage annually, and (2) increase the sample size to approximately 25,000 firms.⁴⁸ As a result of the sample redesign, for 1992 the reported nonmanufacturing share was (and has continued to be) 25–30 percent of total R&D.⁴⁹

TIME-SERIES ANALYSES

The statistics resulting from this survey on R&D spending and personnel are often used as if they were prepared using the same collection, processing, and tabulation methods over time. Such uniformity has not been the case. Since the survey was first fielded, improvements have been made to increase the reliability of the statistics and to make the survey results more useful. To that end, past practices have been changed and new procedures instituted. Preservation of the comparability of the statistics has, however, been an important consideration in making these improvements. Nonetheless, changes to survey definitions, the industry classification system, and the procedure used to assign industry codes to multi-establishment companies have had some, though not substantial, effects on the comparability of statistics.⁵⁰

The aspect of the survey that had the greatest effect on comparability was the selection of samples at irregular intervals (i.e., 1967, 1971, 1976, 1981, 1987, and 1992) and the use of a subset or panel of the last sample drawn to develop statistics for intervening years. As discussed earlier, this practice introduced cyclical deterioration of the statistics. As compensation for this deterioration, periodic revisions were made to the statistics produced from the panels surveyed between sample years. Early in the survey's history, various methods were used to make these revisions.⁵¹ After 1976 and until the 1992 advent of annual sampling, a linking procedure called wedging was used.⁵² In wedging, the 2 sample years on each end of a

series of estimates served as benchmarks in the algorithms used to adjust the estimates for the intervening years.⁵³

COMPARISONS TO OTHER STATISTICAL SERIES

NSF collects data on federally financed R&D from both Federal funding agencies—using the Survey of Federal Funds for Research and Development—and from performers of the R&D—industry, Federal labs, universities, and other nonprofit organizations—using the Survey of Industrial Research and Development and other surveys.⁵⁴ As reported by Federal agencies, NSF publishes data on Federal R&D budget authority and outlays, in addition to Federal obligations. These terms are defined below:⁵⁵

- *Budget authority* is the primary source of legal authorization to enter into obligations that will result in outlays. Budget authority is most commonly granted in the form of appropriations by the congressional committees assigned to determine the budget for each function.

⁵³For a full discussion of the mathematical algorithm used for the wedging process that linked statistics from the 1992 survey with those from the 1987 survey, see U.S. Bureau of the Census (1994g). In general, wedging

takes full advantage of the fact that in the first year of a new panel [when a new sample is selected], both current year and prior-year estimates are derived. Thus, two independent estimates exist for the prior year. The estimates from the new panel are treated as superior primarily because the new panel is based on updated classifications [the industry classifications in the prior panel are frozen] and is more fully representative of the current universe (the prior panel suffers from panel deterioration, especially a lack of birth updating). The limitations in the prior panel caused by these factors are naturally assumed to increase with time, so that in the revised series, we desire a gradual increase in the level or revision over time which culminates in the real difference observed between the two independent sample estimates of the prior year. At the same time, we desire that the annual movement of the original series be preserved to the degree possible in the revised series (U.S. Bureau of the Census, 1994).

To that end, the wedging algorithm does not change estimates from sample years and adjusts estimates from panel years, recognizing that deterioration of the panel is progressive over time. One of the primary reasons for deciding to select a new sample annually rather than at irregular intervals was to avoid applying global revision processes such as wedging. Consequently, the 1992 survey was intended to be the last one affected by the wedging procedure.

⁵⁴For information about and results from other NSF surveys, visit <http://www.nsf.gov/sbe/srs/pubdata.htm>.

⁵⁵NSF (2002b).

⁴⁸Annual sampling also remedies the cyclical deterioration of the statistics that results from changes in a company's payroll composition because of product line and corporate structural changes.

⁴⁹See also NSF (1997, 1998, 1999b, 2000, 2001, and 2002b).

⁵⁰For discussions of each of these changes, see U.S. Bureau of the Census (1994g); for considerations of comparability, see U.S. Bureau of the Census (1993 and 1994e).

⁵¹See U.S. Bureau of the Census (1995).

⁵²The process was dubbed wedging because of the wedgelike area produced on a graph that compares originally reported statistics with the revised statistics that resulted after linking.

- *Obligations* represent the amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when the funds were appropriated or when future payment of money is required.
- *Outlays* represent the amounts for checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated.

National R&D expenditure totals in NSF's *National Patterns of R&D Resources* report series are primarily constructed with data reported by performers and include estimates of Federal R&D funding to these sectors. But until performer-reported survey data on Federal R&D expenditures are available from industry and academia, data collected from the Federal agency funders of R&D

were used to project R&D performance. When survey data from the performers subsequently are tabulated, as they were for this report, these statistics replace the projections based on funder expectations. Historically, the two survey systems have tracked fairly closely. For example, in 1980, performers reported using \$29.5 billion in Federal R&D funding, and Federal agencies reported total R&D funding between \$29.2 billion in outlays and \$29.8 billion in obligations.⁵⁶ In recent years, however, the two series have diverged considerably. The difference in the Federal R&D totals appears to be concentrated in funding of industry, primarily aircraft and missile firms, by the Department of Defense. Overall, industrial firms have reported significant declines in Federal R&D support since 1990 (see table A-1), while Federal agencies have reported level or slightly increased funding of industrial R&D.⁵⁷ NSF continues to identify and examine the factors behind these divergent trends.

⁵⁶NSF (1996b).

⁵⁷NSF (1999a).

SURVEY DEFINITIONS

EMPLOYMENT, FTE R&D SCIENTISTS AND ENGINEERS

Number of people domestically employed by R&D-performing companies who were engaged in scientific or engineering work at a level that required knowledge, gained either formally or by experience, of engineering or of the physical, biological, mathematical, statistical, or computer sciences equivalent to at least that acquired through completion of a 4-year college program with a major in one of those fields. The statistics show full-time-equivalent (FTE) employment of persons employed by the company during the January following the survey year who were assigned full time to R&D, plus a prorated number of employees who worked part time on R&D.

EMPLOYMENT, TOTAL

Number of people domestically employed by R&D-performing companies in all activities during the pay period that includes the 12th of March, the date most employers use when paying first quarter employment taxes to the Internal Revenue Service.

FEDERALLY FUNDED R&D CENTERS (FFRDCs)

R&D-performing organizations administered by industrial, academic, or other institutions on a nonprofit basis, and exclusively or substantially financed by the Federal Government. For the statistics in this report, R&D expenditures of industry-administered FFRDCs were included with the Federal R&D data of the industry classification of each of the administering firms. The industry-administered FFRDCs included in the 2000 survey, their corporate administrators, and location are indicated below.⁵⁸

FFRDCs SUPPORTED BY THE DEPARTMENT OF ENERGY

- Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, administered by

Lockheed Martin Idaho Technologies Co.

- Sandia National Laboratories, Albuquerque, NM, administered by Sandia Corporation a subsidiary of Lockheed Martin Corp.
- Savannah River Technology Center, Aiken, SC, administered by Westinghouse Corp.

FFRDC SUPPORTED BY THE DEPARTMENT OF HEALTH AND HUMAN SERVICES, NATIONAL INSTITUTES OF HEALTH

- National Cancer Institute (NCI) Frederick Cancer Research Facility, Frederick, MD, administered by Science Applications International Corporation, Advanced Bioscience Laboratories, Inc., Charles River Laboratories, Inc., and Data Management Services, Inc.

FUNDS FOR R&D, COMPANY AND OTHER NON-FEDERAL

The cost of R&D performed within the company and funded by the company itself or by other non-Federal sources; does not include the cost of R&D supported by the company but contracted to outside organizations such as research institutions, universities and colleges, nonprofit organizations, or—to avoid double-counting—other companies.

FUNDS FOR R&D, FEDERAL

The cost of R&D performed within the company under Federal R&D contracts or subcontracts and R&D portions of Federal procurement contracts and subcontracts; does not include the cost of R&D supported by the Federal Government but contracted to outside organizations such as research institutions, universities and colleges, nonprofit organizations, or other companies.

FUNDS FOR R&D, TOTAL

The cost of R&D performed within the company in its own laboratories or in other company-owned or company-operated facilities, including expenses for wages

⁵⁸For current lists of FFRDCs, visit <http://www.nsf.gov/sbe/srs/ffrdc/start.htm>.

and salaries, materials and supplies, property and other taxes, maintenance and repairs, depreciation, and an appropriate share of overhead; does not include capital expenditures or the cost of R&D contracted to outside organizations such as research institutions, universities and colleges, nonprofit organizations, or—to avoid double-counting—other companies.

FUNDS PER R&D SCIENTIST OR ENGINEER

All costs associated with the performance of industrial R&D (salaries, wages, and fringe benefits paid to R&D personnel; materials and supplies used for R&D; depreciation on capital equipment and facilities used for R&D; and any other R&D costs) divided by the number of R&D scientists and engineers employed. To obtain a per person cost of R&D for a given year, the total R&D expenditures of that year were divided by an approximation of the number of full-time-equivalent (FTE) scientists and engineers engaged in the performance of R&D for that year. For accuracy, this approximation was the mean of the numbers of such FTE R&D-performing scientists and engineers as reported in January for the year in question and the subsequent year. For example, the mean of the numbers of FTE R&D scientists and engineers in January 2000 and January 2001 was divided into total 2000 R&D expenditures for a total cost per R&D scientist or engineer in 2000.

NET SALES AND RECEIPTS

Dollar values for goods sold or services rendered by R&D-performing companies to customers outside the company—including the Federal Government—less such items as returns, allowances, freight, charges, and excise taxes. Domestic intracompany transfers and sales by foreign subsidiaries were excluded, but transfers to foreign subsidiaries and export sales to foreign companies were included.

R&D AND INDUSTRIAL R&D

R&D is the planned, systematic pursuit of new knowledge or understanding toward general application (basic research); the acquisition of knowledge or understanding to meet a specific, recognized need (applied research); or the application of knowledge or understanding toward the production or improvement of a product, service, process, or method (development). *Basic research* analyzes properties, structures, and relationships toward formulating and testing hypotheses, theories, or laws; *applied research* is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving specific, predetermined objectives; and *development* draws on research findings or other scientific knowledge for the purpose of producing new or significantly improving products, services, processes, or methods. As used in this survey, industrial *basic research* is the pursuit of new scientific knowledge or understanding that does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest; industrial *applied research* is investigation that may use findings of basic research toward discovering new scientific knowledge that has specific commercial objectives with respect to new products, services, processes, or methods; and industrial *development* is the systematic use of the knowledge or understanding gained from research or practical experience directed toward the production or significant improvement of useful products, services, processes, or methods, including the design and development of prototypes, materials, devices, and systems. The survey covers industrial R&D performed by people trained—either formally or by experience—in engineering or in the physical, biological, mathematical, statistical, or computer sciences and employed by a publicly or privately owned firm engaged in for-profit activity in the United States. Specifically excluded from the survey are quality control, routine product testing, market research, sales promotion, sales service, and other nontechnological activities; routine technical services; and research in the social sciences or psychology.

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